JUTE SPINNING AND WEAVING CALCULATIONS

KAR

By the same author

- AN INTRODUCTION TO JUTE SPINNING
- THE JUTE FIBRE

Rs. 15/-

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JUTE
SPINNING AND WEAVING CALCULATIONS

By the same author

AN INTRODUCTION TO JUTE SPINNING

An approved text-book

of the

Institute of Jute Technology

THE JUTE FIBRE

With an introduction by

C. R. Nodder

Principal, Institute of Jute Technology

JUTE SPINNING AND WEAVING CALCULATIONS

S. N. Kar

AUTHOR OF 'AN INTRODUCTION TO JUTE SPINNING' & 'THE JUTE FIBRE'

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PREFACE

In presenting this volume the author desires to record his hearty appreciation of the kind reception given to his books, *An Introduction to Jute Spinning* and *The Jute Fibre.*

The need for a comprehensive book dealing with the calculations necessary in jute spinning and weaving, has encouraged the author to write this volume. This book contains, in addition to the calculations, concise description of the operations in the batching, preparing, spinning, winding, beaming, weaving and finishing departments with a large number of illustrations. Though this book is intended for the students and apprentices, many others connected with the jute industry may find it helpful.

The author expresses his indebtedness to Dr. B. K. Chakravarti, M. Sc., D. Phil., F. T. I., Professor, Institute of Jute Technology, Calcutta, who was so kind as to take the trouble of looking over the chapter dealing with Quality Control and suggesting improvements. The author also takes this opportunity to express his thanks to Mr. R. McCauley of Messrs James Mackie & Son, Limited, Belfast for supplying information about modern preparing and spinning machinery.

Inspite of the best of precaution and care, some errors may have crept in the book. The author will gratefully receive intimation of such errors.

The author trusts that this volume will be received as favourably as its predecessors.

August, 1961
Calcutta

S. N. Kar

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CHAPTER I

TRANSMISSION OF MOTION

Belt Drive

One of the common methods of communicating motion to a shaft from a parallel shaft at a moderate distance away, is by means of an endless belt, running over pulleys. In the open-belt drive, the driver pulley or drum drives the driven pulley in the same direction. In the crossed-belt drive, the driver pulley drives the driven one in the opposite direction.

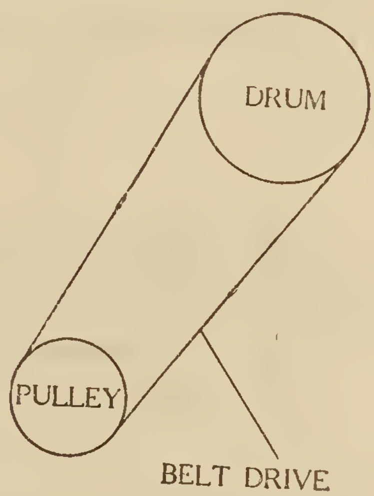
$$R \times \frac{D}{D_1} = R_1$$

R = Revolutions of the driving shaft

R_1 = Revolutions of the driven shaft

D = Diameter of the drum on the driving shaft

D_1 = Diameter of the pulley on the driven shaft.



Belt Drive

When the shafts are not connected directly but counter shafts are employed to connect them the calculation will be as follows :

$$R \times \frac{P}{P_1} = R_1$$

R = Revolutions of the first driver pulley

R_1 = Revolutions of the last driven pulley

P = Product of the diameters of all driver pulleys

P_1 = Product of the diameters of all driven pulleys.

Rope Drive

Ropes are used instead of belts to convey motion from one shaft to another parallel shaft when the shafts are at a considerable distance apart. The rope drive requires pulleys with grooves to reduce the tendency to slip.

Chain Drive

When the tension is very high and slipping is to be reduced to nil, chain and wheel arrangement is preferred to belts and ropes.

Friction Drive

If the outsides of two wheels, on two different shafts which are parallel to one another are in close contact, the motion may be conveyed from one shaft to the other, provided the surfaces of the wheels are not polished and the resistance of the driven wheel is not considerable.

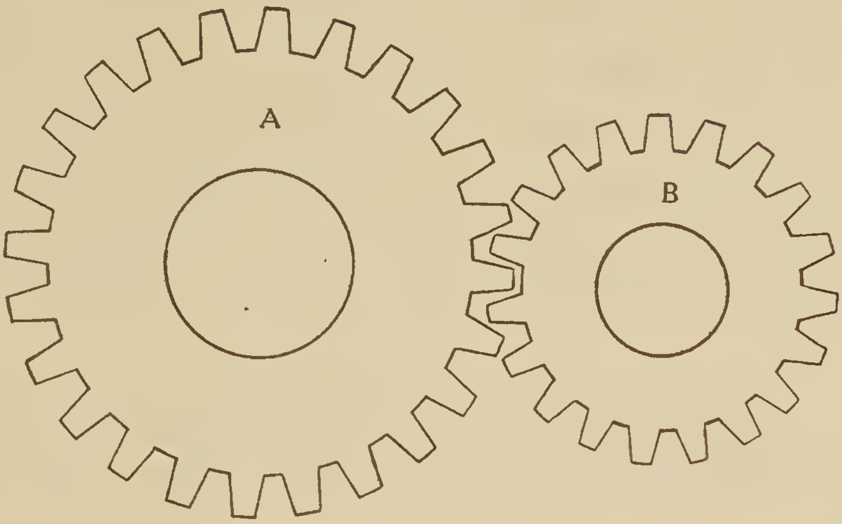
$$\frac{R_1}{R} = \frac{D}{D_1}$$

R = Revolutions of the driving wheel
R_1 = Revolutions of the driven wheel
D = Diameter of the driving wheel
D_1 = Diameter of the driven wheel.

Toothed Wheel Gearing

When two toothed wheels are in gear, they rotate in opposite directions and the speeds of the circumferences of the two wheels are same. Let us suppose a wheel A having 48 teeth, is in gear with another wheel B having 16 teeth. When A makes one revolution its 48 teeth must engage 48 teeth of B. B having only 16 teeth, will make $48 \div 16 = 3$

revolutions for one revolution of A. If A makes 10 revolutions per minute, $10 \times 48 = 480$ teeth of A must engage



Toothed Wheel Gearing

480 teeth of B per minute. So B must make $480 \div 16 = 30$ revolutions per minute.

$$R \times T = R_1 \times T_1$$

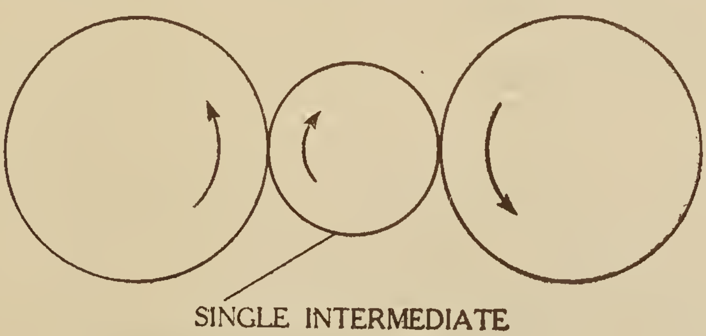
R = Revolutions of driver wheel per minute

R_1 = Revolutions of driven wheel per minute

T = Teeth in the driver wheel

T_1 = Teeth in the driven wheel.

One or more Intermediates or Single Carriers on separate axles, are used to bridge space between two wheels on

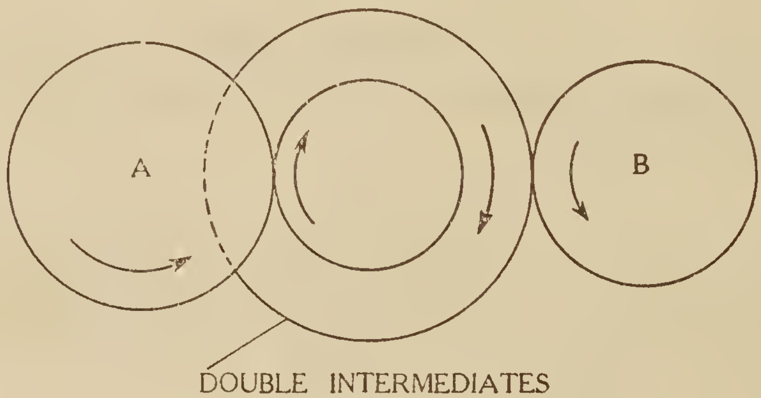


Single Intermediate

parallel shafts when these shafts are so far apart that the wheels on these cannot be put into gear directly. The

intermediates being both driver and driven at the same time, have no influence on the relative speeds of the wheels they connect and may be ignored in the calculations. But the direction of rotation of the wheels are affected by the connecting intermediates. Two wheels, which are connected by an even number of intermediates, will rotate in opposite directions. They will rotate in the same direction if an odd number of intermediates are used between them.

One or more Double Intermediates or Compound Carriers are used between two shafts when the speed of



Double Intermediates

one shaft in relation to the other is to be increased or reduced to a great extent.

In a train of wheels,

$$V = \frac{P}{P_1}$$

$$R \times V = R_1$$

V = Value of the train

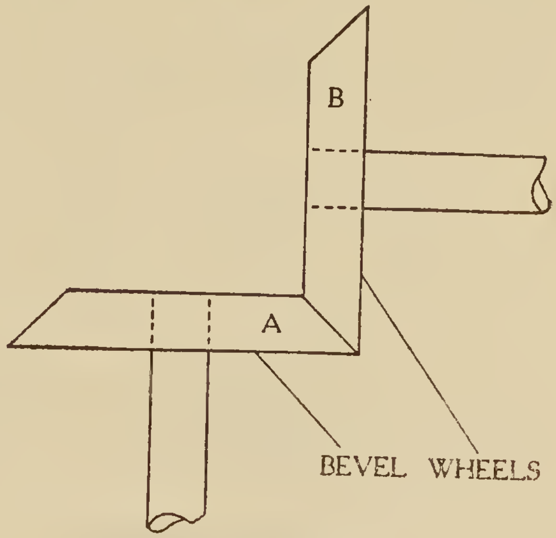
P = Product of teeth of all driver wheels

P_1 = Product of teeth of all driven wheels

R = Revolutions of the first driver wheel

R_1 = Revolutions of the last driven wheel.

Bevel wheels are used to connect non-parallel shafts usually at right angles. Let us suppose a bevel wheel A is in gear with another bevel wheel B. Then the relative speeds of A and B will be same as in case of two ordinary wheels in gear with the same number of teeth.



Bevel Wheels

$$R \times \frac{T}{T_1} = R_1$$

R = Revolutions of A
R_1 = Revolutions of B
T = Teeth in A
T_1 = Teeth in B.

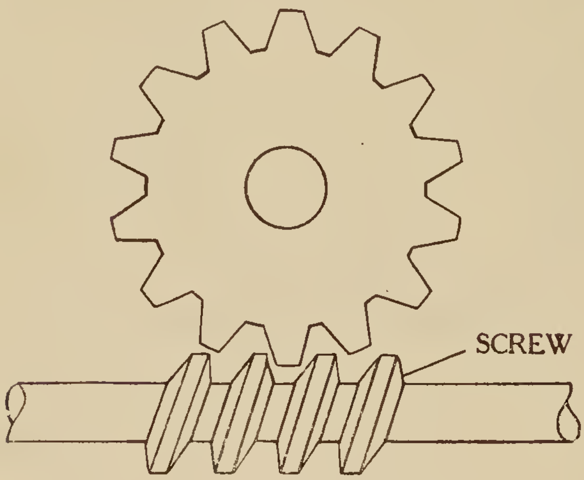
Screws

Screws are conveniently employed to produce a forward sliding motion directly from one of rotation. When movable bars are in contact with the thread of a screw, the bars will be driven forward a distance equal to the pitch of the screw for one revolution of the screw. The screws are usually single-threaded, double-threaded or three-threaded.

Worm Gearing

The arrangement of Screw and Worm-wheel is employed when a considerable reduction in speed is desired but there is little space to place double intermediates or a large wheel is to be driven by a very small wheel which is not practicable. If a single-threaded screw is

in gear with a worm-wheel of 48 teeth, 48 revolutions of the screw will give the worm-wheel one revolution only.



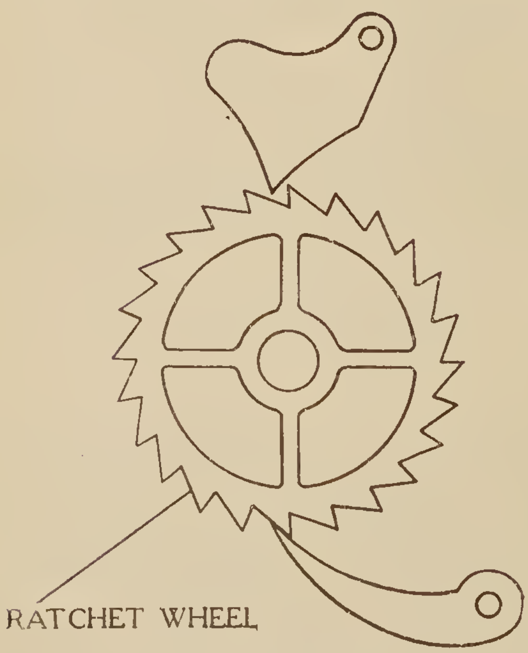
Worm Gearing

A double-threade screwd will require $48 \div 2 = 24$ revolutions to give the worm-wheel one complete revolution. A three-threaded screw will rotate $48 \div 3 = 16$ times when the worm-wheel will complete one revolution.

$$V = \frac{T}{N}$$

V = Velocity ratio
T = Teeth in worm-wheel
N = Number of threads in the screw.

Ratchet Wheels

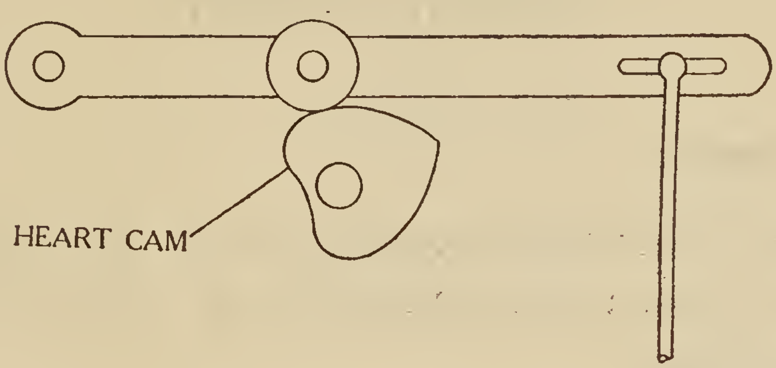


Ratchet Wheel

When conversion of reciprocating or to and fro motion into intermittent rotary motion is desired, Ratchet wheels are used.

Cams

Cams are employed for converting a rotary motion into a reciprocating motion. These are usually in the form of plates and discs. The rotating discs convey the



Heart Cam

motion to the pieces connected to them. The shapes of the edges of the cams or grooves in their surfaces, control the nature of the motion.

CHAPTER II

SURFACE SPEED

Surface Speed

When a roller revolves, any point on the surface of the roller will travel a distance equal to its circumference for each revolution.

$$S'' = R \times D \times 3{\cdot}14$$

$$S' = \frac{R \times D \times 3{\cdot}14}{12}$$

$$R = \frac{S''}{D \times 3{\cdot}14}$$

$$R = \frac{S' \times 12}{D \times 3{\cdot}14}$$

S'' = Surface speed of the roller in inches per minute
S' = Surface speed of the roller in feet per minute
R = Revolutions of the roller per minute
D = Diameter of the roller in inches.

Draft

When two revolving rollers A and B, with pressing rollers placed above them, act on a sliver and the surface speed of B is greater than that of A, the sliver is elongated. The amount of elongation of the sliver is the draft between the rollers B and A. Thus, the draft is a numerical figure

being the ratio of the surface speed of the faster roller to that of the slower roller.

$$P = \frac{S}{S_1}$$

$$= \frac{R \times D \times 3{\cdot}14}{R_1 \times D_1 \times 3{\cdot}14}$$

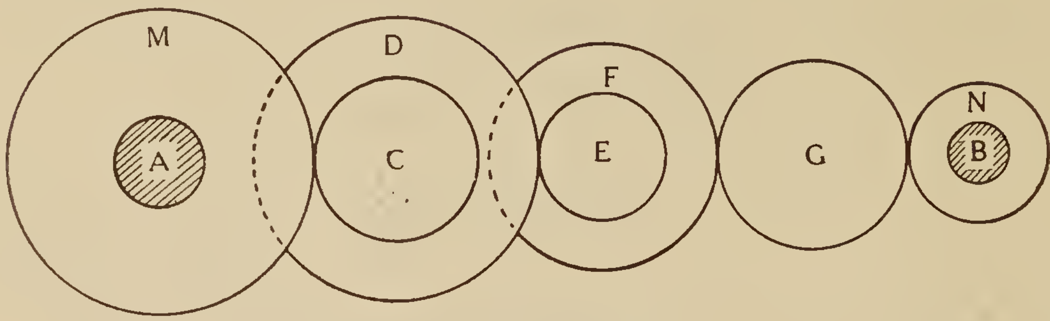
$$= \frac{R \times D}{R_1 \times D_1}$$

P = Draft between the rollers B and A
S = Surface speed of B in inches per minute
S_1 = Surface speed of A in inches per minute
R = Revolutions of B per minute
R_1 = Revolutions of A per minute
D = Diameter of B in inches
D_1 = Diameter of A in inches.

The draft between two rollers is 12. This means that the surface speed of the faster roller is 12 times greater than that of the slower roller. Thus, 1 yard of the material on the slower roller, produces 12 yards of the material on the other roller and therefore the weight of the material per unit length on the faster roller is 12 times lighter than the weight of the material per unit length on the slower roller.

The draft is usually calculated from the train of gearing. Let us suppose that the motion is transmitted from a wheel M on roller A to another wheel N on roller B through two double intermediates C/D and E/F and a

single intermediate G. The surface speed of B is greater than that of A.



TRAIN OF GEARING

Train of Gearing

$$P = \frac{b \times 3{\cdot}14}{n} \times \frac{f}{e} \times \frac{d}{c} \times \frac{m}{a \times 3{\cdot}14}$$

P = Draft between the rollers B and A
m = Teeth in the wheel M
c = Teeth in the wheel C
d = Teeth in the wheel D
e = Teeth in the wheel E
f = Teeth in the wheel F
n = Teeth in the wheel N
a = Diameter of roller A in inches
b = Diameter of roller B in inches.

Draft Constant

Often the draft of a machine is changed. Usually this is done by changing a fixed wheel in the train. This wheel is called the Change Pinion or the Draft Pinion. Let us assume that the wheel C is the draft pinion in the above train of gearing. Taking the value of the wheel C as 1 instead of the number of its teeth in the train of gearing,

$$\frac{b \times 3{\cdot}14}{n} \times \frac{f}{e} \times \frac{d}{1} \times \frac{m}{a \times 3{\cdot}14} = K, \text{ a constant.}$$

This constant K is called the Draft Constant.

$$P = \frac{K}{c}$$

$P =$ Draft
$c =$ Teeth in C (draft pinion).

In the above calculation, the draft pinion is on the denominator side.

The draft pinion may be on the numerator side also. Let us assume that the wheel D is the change pinion instead of the wheel C in the train of gearing.

$$\frac{b \times 3{\cdot}14}{n} \times \frac{f}{e} \times \frac{1}{c} \times \frac{m}{a \times 3{\cdot}14} = K$$

$$P = K \times d$$

Lead

When the surface speed of a roller is slightly greater than that of another roller, the slight excess surface speed of the faster roller over the surface speed of the slower one is called the Lead. It is expressed as a percentage figure calculated on the surface speed of the slower roller.

If a roller A travels m inches per minute and another roller B travels n inches per minute, n being slightly greater than m,

$$L = \frac{n - m}{m} \times 100$$

$L =$ Lead of roller B over roller A
$m =$ Surface speed of A in inches per minute
$n =$ Surface speed of B in inches per minute.

CHAPTER III

BATCHING

Moisture in Jute

The jute fibre contains some amount of moisture which is expressed as Moisture Regain or Moisture Content. Moisture Regain is the percentage of moisture, calculated on the oven-dry weight of the fibre. Moisture Content is the percentage of moisture, calculated on the undried weight of the fibre.

$$R = \frac{a-b}{b} \times 100$$

$$C = \frac{a-b}{a} \times 100$$

R = Moisture Regain %
C = Moisture Content %
a = Undried weight of the fibre
b = Oven-dry weight of the fibre.

Thus, if 100 parts by weight of the jute fibre contain 15 parts by weight of moisture, the moisture regain is $\frac{15}{85} \times 100 = 17{\cdot}65\%$ and the equivalent moisture content is $\frac{15}{100} \times 100 = 15\%$.

In raw jute trade, the standard regain % is 13·75 which is rather low and a value of 16-17% regain is considered satisfactory. The assessment of moisture in raw jute is very important. The purchase of raw jute containing moisture in excess of its standard regain is equivalent to

buying some water in place of jute. The following example will explain it better :

Total jute purchased	...	500 mds.
Standard regain	...	16%
Original weight of a sample of the jute	...	180 lbs.
Dry weight of the sample	...	150 lbs.
16% of dry weight	...	24 lbs.
Correct condition weight	...	$150+24=174$ lbs.
Excess moisture	...	$180-174=6$ lbs.
% excess moisture	...	$\frac{6}{180}\times 100=3{\cdot}33$

This means a loss of 16·65 mds. of jute in a transaction of 500 mds. This is equivalent to a financial loss of Rs 499·5 if the price of jute is Rs. 30 per md. This may be considered from another angle. If the jute contains more moisture than it should contain, more quantity of jute will be required in the Batching department for the same quantity of production.

Batch

In jute industry batching is the blending of jute of different qualities and colours to produce a yarn of uniform strength and colour. In a wider sense the term 'batching' includes all the processes, preparatory to carding. A batch is a number of bales of jute, arranged to produce a particular type of yarn. The number of bales of different marks which are selected to produce Hessian Warp Yarn, constitutes hessian warp batch. Hessian warp jute should be strong, fairly long, clean, free from all sorts of defects and of good colour and lustre. Hessian weft jute should be moderately strong, clean,

reasonably free from defects and of fair colour and lustre. Sacking warp jute should be strong, fairly long, clean, reasonably free from defects and of any colour. Sacking weft jute is the lowest quality. Weak jute, rejections and defective jute are mixed with root-cuttings to produce sacking weft yarn.

Batch Price

Batches are arranged with due consideration for prices, stocks, duration and suitability for spinning and weaving. Batch price is one of the important factors which determine the profit of a jute mill. This is the average price of jute consumed usually expressed as rupees per maund. The batch price is calculated in the following way :

Mark	*No. of Bales*	*Mds. per Bale*	*Total Mds.*	*Rs. per Md.*	*Total Rs.*
Dhubri *Mid*	8	4	32	26·00	832·00
Haldibari *Top*	8	4	32	26·00	832·00
Dinhata *Mid*	8	3·5	28	25·00	700·00
Kissengunje *Mid*	8	4	32	24·50	784·00
Coochbehar Mesta *Mid*	10	4	40	23·00	920·00
Purnea Mesta *Mid*	10	4	40	22·50	900·00
Agartalla Tossa *Mid*	12	1·5	18	26·00	468·00
Karimpur Tossa *Mid*	6	4	24	24·00	576·00
Nowgong *Bot*	12	4	48	23·00	1104·00
Basirhat *Bot*	12	3	36	21·50	774·00
Dalkhola *Bot*	24	1·5	36	22·50	810·00
Sahebgunj *Bot*	12	3·5	42	21·50	903·00
Sheoraphuli Daisee *Bot*	16	3·5	56	24·00	1344·00
Cossimbazar Tossa *Bot*	16	3·5	56	23·00	1288·00

Mark	*No. of Bales*	*Mds. per Bale*	*Total Mds.*	*Rs. per Md.*	*Total Rs.*
Samsi Mesta *Bot*	20	1·5	30	21·00	630·00
Bongaon Mesta *Bot*	10	4	40	20·50	820·00
Dhulian X *Bot*	12	3·5	42	18·00	756·00
Cutting *N. C.*	12	5	60	16·00	960·00
			692		15401·00

Batch price = Rs. 15401 ÷ 692 = Rs. 22·25 per maund.

Batching

In hand-batching, suitably sized morahs of jute made by the selectors, are treated with oil and water. After conditioning these are passed through the Softener.

In machine-batching, the jute is lubricated during its passage through the softener and then it is conditioned if necessary.

Jute is a ligno-cellulose type of fibre. Its woody nature and low fat and wax content, make it unsuitable for processing in the dry condition. The fibre is rendered suitable for spinning by lubricating it at the early stage of processing. An emulsion of oil and water is usually applied to jute. An average emulsion should contain 0·5-1% emulsifying agent, 22·5-24% mineral oil and 75-77% water. With uniform application 2% oil on the weight of jute is sufficient. But such uniformity is not possible in the industry. Under normal conditions, the amount of oil applied to jute should not exceed 5%.

The root-ends of long jute are usually cut by knives after lubrication and conditioning. Root Combers and Jute Snippers may be used to comb and clean the root-

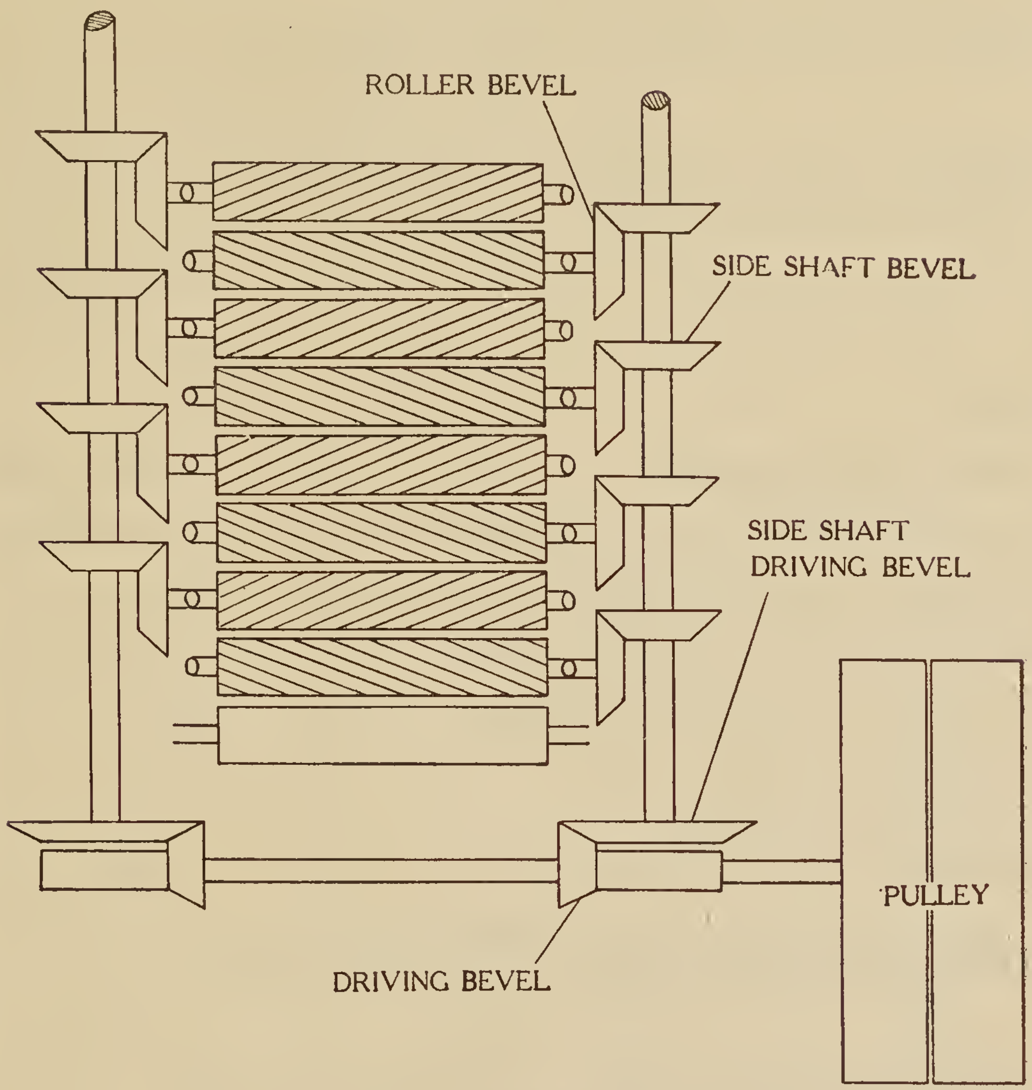
ends. The root-cuttings from the knife line are mixed with the cuttings from bales and then lubricated while passing through the softener after which these cuttings are piled for a few days.

The jute ropes binding the jute bales, are cut into pieces which are lubricated in a softener and then teased in a Rope Teaser. The rove waste from the roving and the spinning departments is lubricated and cut into pieces. The thread waste from the winding, beaming and weaving departments is also treated in the same way. The gunny cuttings from the finishing department are lubricated and then teased in a Gunny Teaser. The caddis from all the departments is cleaned in a Dust Shaker. The clean caddis is mixed with the root-cuttings. All these wastes are mixed up and passed through the Waste Teaser to form tow.

The Softener

A softener of average size contains 63 pairs of rollers, each pair consisting of one bottom roller and one top roller. These rollers are spirally fluted. The direction of the spirals is changed in each pair of rollers. The first and the last pair of rollers are usually straight fluted. The top roller is pressed down on the bottom roller by adjustable springs. A distance piece is placed between the rollers to keep them slightly apart. The drum on the driving shaft, drives the pulleys on the cross shaft. The two driving bevels on the cross shaft are in gear with two side shaft driving bevels. The bottom roller bevels are geared with the bevels on the two side shafts, one roller

with either shaft alternately. The top rollers are driven in contact with the bottom ones.



Softener

Driving shaft speed	...	*A* revs. per min.
Diameter of drum	...	*b* inches
Diameter of pulley	...	*c* ,,
Cross shaft driving bevel pinion		*D* teeth
Side shaft driving bevel wheel		*E* ,,
Side shaft bevel pinion	...	*F* ,,
Roller bevel wheel	...	*G* ,,
Diameter of roller	...	*h* inches

$$\text{Pulley shaft speed} = A \times \frac{b}{c} \text{ r. p. m.}$$

$$\text{Roller speed} = A \times \frac{b}{c} \times \frac{D}{E} \times \frac{F}{G} \text{ r. p. m.}$$

$$\text{Roller surface speed} = A \times \frac{b}{c} \times \frac{D}{E} \times \frac{F}{G} \times \frac{h \times 3{\cdot}14}{12} \text{ ft. per min.}$$

Example

Driving shaft speed	..	147 r. p. m.
Diameter of drum on driving shaft	...	48 inches
Diameter of pulleys on cross shaft	...	48 ,,
Cross shaft driving bevel pinion	...	18 teeth
Side shaft driving bevel wheel	...	40 ,,
Side shaft bevel pinion	...	16 ,,
Roller bevel wheel	...	25 ,,
Diameter of roller	...	5·5 inches

$$\text{Pulley shaft speed} = 147 \times \frac{48}{48} = 147 \text{ r. p. m.}$$

$$\text{Roller speed} = 147 \times \frac{18}{40} \times \frac{16}{25} = 42{\cdot}34 \text{ r. p. m.}$$

$$\text{Roller surface speed} = 42{\cdot}34 \times \frac{5{\cdot}5 \times 3{\cdot}14}{12} = 60{\cdot}93 \text{ ft. per min.}$$

The Jute Good's Machine

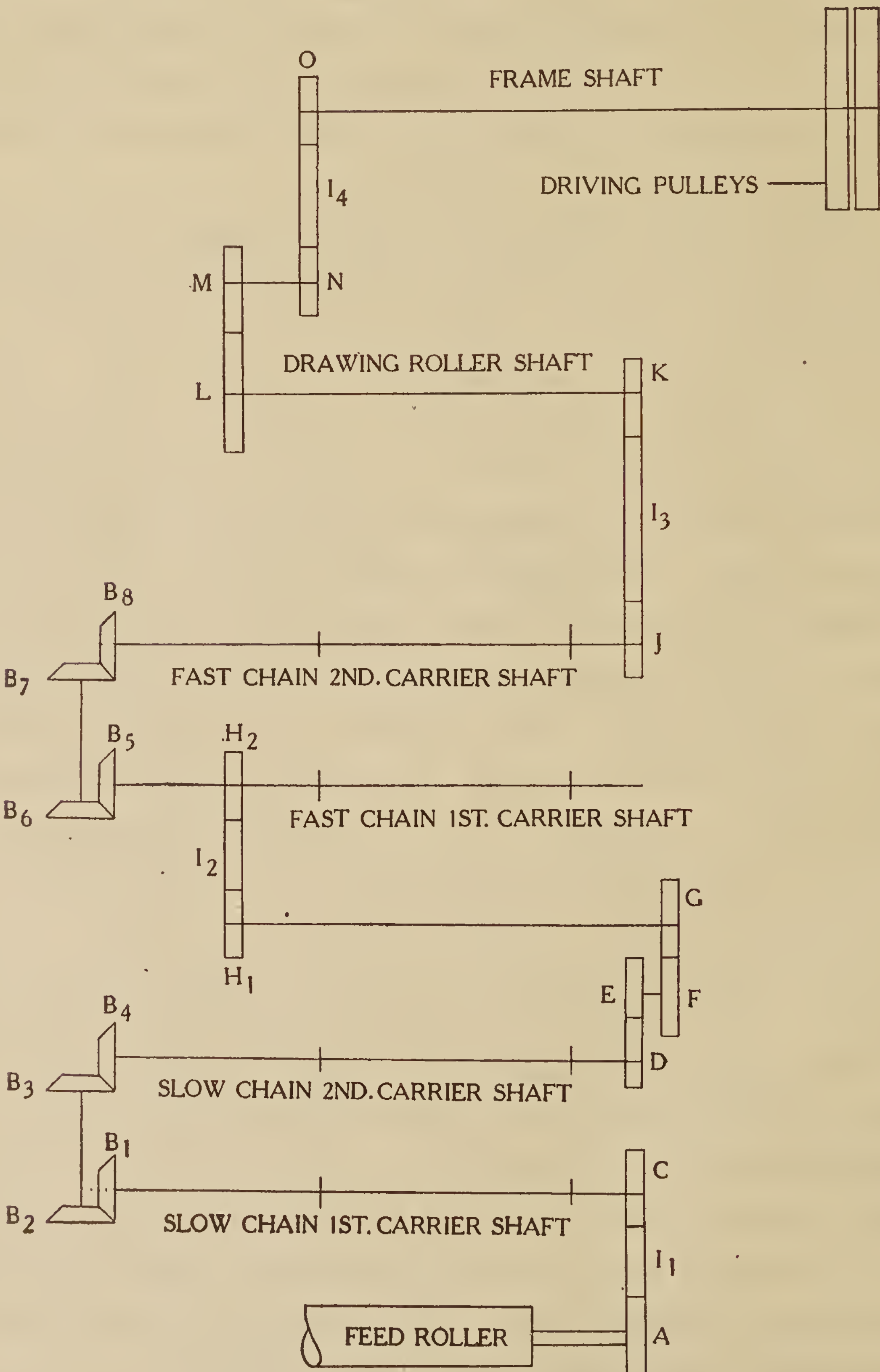
The Jute Good's Machine has started to replace the softener as the former ensures considerable saving in labour, even distribution and penetration of batching emulsion in the fibre and transport facilities.

The Jute Spreading, Softening and Hackling machine (Fairbairn Lawson Combe Barbour) consists of a feed sheet, six pairs of straight-fluted rollers loaded with adjustable springs, feed rollers, slow chain, fast chain, drawing rollers, conductor and roll-former.

The root-ends of selected morahs of jute each weighing about 2 lbs., are cut off and the morahs are placed on a barrow in layers. The full barrow is placed on a weighing platform equipped with a Dormant scale. There are two pointers concentrically mounted on the dial of the scale. As the morahs of jute are taken from the barrow and fed into the machine, one pointer of the scale indicates the diminishing weight of jute. The other pointer of the scale being connected to the feed sheet roller of the machine through a flexible drive, moves when the feed sheet roller rotates. For uniform feeding these two pointers should keep pace and coincide with each other. The jute passes through the softening rollers, the feed rollers and is finally taken up by the slow chain consisting of hackle pin bars conveyed by links. Good pinning is ensured by the lead of slow chain over the feed rollers. The cage rollers press the fibres into the pins of the slow chain. The lead of fast chain over the slow chain enables the faster moving pins of the fast chain to hackle the jute while it is retained by the pins of the slow chain. After this the material is taken up by the drawing rollers. The sliver then passes over the conductor where batching emulsion is sprayed on it by means of a pressure spray and finally made into a roll in the roll-former.

The driving pulleys on the frame shaft are driven by an electric motor. The pinion O on the other end of

the frame shaft drives the drawing roller wheel L through



Drive to Jute Spreading, Softening and Hackling Machine (F. L. C. B.)

a single intermediate I_4 and a double intermediate N/M. The pinion K on the other end of the drawing roller drives the fast chain 2nd. carrier shaft wheel J through a single intermediate I_3. This motion is conveyed to the 1st. carrier shaft through two pairs of bevel wheels B_8/B_7 and B_6/B_5. The pinion H_2 on the 1st. carrier shaft drives the wheel H_1 on a parallel shaft through a single intermediate I_2. The wheel G on the shaft of H_1, drives the slow chain 2nd. carrier shaft wheel D through a double intermediate F/E. This drive is conveyed to the 1st. carrier shaft through two pairs of bevel wheels B_4/B_3 and B_2/B_1. The pinion C on the 1st. carrier shaft drives the feed roller wheel A through a single intermediate I_1.

Draft between drawing roller and feed roller

$$=\frac{d}{K}\times\frac{J}{B_8}\times\frac{B_7}{B_6}\times\frac{B_5}{H_2}\times\frac{H_1}{G}\times\frac{F}{E}\times\frac{D}{B_4}\times\frac{B_3}{B_2}\times\frac{B_1}{C}\times\frac{A}{f}$$

where d = Circumference of drawing roller in inches

f = Circumference of feed roller in inches.

As all the bevel wheels are equal, these cancel one another.

$$\text{Draft} = \frac{d}{K}\times\frac{J}{H_2}\times\frac{H_1}{G}\times\frac{F}{E}\times\frac{D}{C}\times\frac{A}{f}.$$

Example

Diameter of drawing roller	...	6	inches
Pinion on drawing roller	...	26	teeth
Fast chain 2nd. carrier shaft wheel		38	,,
Pinion on fast chain 1st. carrier shaft		21	,,
Parallel shaft wheel	...	21	,,
Pinion on off end of parallel shaft		20	,,
Double intermediate	...	70/36	,, (change)

Slow chain 2nd. carrier shaft wheel	72	teeth
Pinion on off end of slow chain 1st. carrier shaft	40	„
Feed roller wheel	39	„
Diameter of feed roller ...	6	inches

$$\text{Draft Constant} = \frac{6}{26} \times \frac{38}{21} \times \frac{21}{20} \times \frac{70}{1} \times \frac{72}{40} \times \frac{39}{6} = 359{\cdot}1$$

$$\text{Draft} = \frac{\text{Draft Constant}}{\text{Change Pinion}} = \frac{359{\cdot}1}{36} = 9{\cdot}98.$$

The Jute Good's Machine (Mackie) consists of a feed sheet, feed rollers, slow-moving bars carrying hackle pins, fast-moving bars carrying hackle pins, drawing rollers, back conductor, delivery rollers, front conductor and roll-former.

A clock is attached to the feed roller. A fixed quantity of jute is weighed and spread on the feed sheet for one revolution of the pointer of the clock. The feed roller takes the jute from the feed sheet and passes it to the slow-moving bars. Then the jute is taken up by the fast-moving bars. The hackle pins of the fast-moving bars hackle the jute as it is retained by the hackle pins of the slow-moving bars. The drawing rollers take the fibre as it comes out of the fast-moving bars. The sliver from the drawing rollers is condensed in the back conductor and delivered by the delivery rollers. Then the sliver passes over the front conductor where it is lubricated by the pressure spray and finally formed into a roll in the roll-former.

The Teaser Card

Cuttings, rove waste, thread waste, teased gunny cuttings and ropes, clean caddis and other waste materials

are mixed up and made into tow in a single or tandem teaser card. The hard fibres and all sorts of waste are treated in the teaser card to make those suitable for subsequent operation. The teaser card is more or less similar to breaker card. The main parts responsible for the carding action are cylinder, feed roller, workers, strippers and doffer as in the case of a breaker card. The action of these rollers will be explained in connection with the breaker card. The direction of rotation of the feed roller may be changed by means of a reverse gear.

In a teaser card (Low) a belt drive conveys the motion from the drum on the driving shaft to the pulleys on the cylinder arbor. The stripper pulleys are driven by the stripper-driving pulley on the same arbor behind the driving pulleys through belting. The cylinder pinion on the same arbor, drives the feed roller wheel through one single intermediate and two double intermediates, one of them being with reverse gear. The cylinder pinion, again, drives the drawing roller wheel through two intermediates. The doffer wheel is driven by the pinion on the other end of the drawing roller through one double intermediate. The cylinder pinion, again, drives the first worker wheel through a single intermediate and a double intermediate. The first worker wheel in turn drives the second worker wheel through a single intermediate.

Driving shaft speed	...	...	A r. p. m.
Diameter of drum	...	...	b inches
Diameter of pulley	...	...	b_1 ,,
Diameter of cylinder	...	...	b_2 ,,
Cylinder pinion	...	...	C teeth

Double intermediates (cylinder to feed roller) ...	... D/D_1, $E/E_1/E_2$	teeth
Feed roller wheel ...	... F	teeth
Drawing roller wheel (cylinder to drawing roller) ...	G	,,
Pinion on off end of drawing roller ...	G_1	,,
Double intermediate (drawing roller to doffer) ...	H/H_1	,,
Doffer wheel ...	... I	,,
Double intermediate (cylinder to worker) ...	J/J_1	,,
1st. and 2nd. worker wheels ...	K	,,
Diameter of feed roller ...	... l	inches
Diameter of drawing roller	m	,,
Diameter of doffer ...	... n	,,
Diameter of worker ...	... o	,,
Diameter of stripper ...	... p	,,
Diameter of stripper driving pulley ...	p_1	,,
Diameter of stripper pulley ...	p_2	,,

Cylinder speed :

$$A \times \frac{b}{b_1} \text{ r. p. m.}$$

$$A \times \frac{b}{b_1} \times \frac{b_2 \times 3{\cdot}14}{12} \text{ ft. per min.}$$

Feed Roller speed :

$$A \times \frac{b}{b_1} \times \frac{C}{D} \times \frac{D_1}{E} \times \frac{E_1}{F} \text{ r. p. m.}$$

$$A \times \frac{b}{b_1} \times \frac{C}{D} \times \frac{D_1}{E} \times \frac{E_1}{F} \times \frac{l \times 3{\cdot}14}{12} = Y \text{ ft. per min.}$$

Stripper speed :

$$A \times \frac{b}{b_1} \times \frac{p_1}{p_2} \text{ r. p. m.}$$

$$A \times \frac{b}{b_1} \times \frac{p_1}{p_2} \times \frac{p \times 3{\cdot}14}{12} \text{ ft. per min.}$$

Worker speed :

$$A \times \frac{b}{b_1} \times \frac{C}{J} \times \frac{J_1}{K} \text{ r. p. m.}$$

$$A \times \frac{b}{b_1} \times \frac{C}{J} \times \frac{J_1}{K} \times \frac{o \times 3{\cdot}14}{12} \text{ ft. per min.}$$

Drawing roller speed :

$$A \times \frac{b}{b_1} \times \frac{C}{G} \text{ r. p. m.}$$

$$A \times \frac{b}{b_1} \times \frac{C}{G} \times \frac{m \times 3{\cdot}14}{12} = Z \text{ ft. per min.}$$

Doffer speed :

$$A \times \frac{b}{b_1} \times \frac{C}{G} \times \frac{G_1}{H} \times \frac{H_1}{I} \text{ r. p. m.}$$

$$A \times \frac{b}{b_1} \times \frac{C}{G} \times \frac{G_1}{H} \times \frac{H_1}{I} \times \frac{n \times 3{\cdot}14}{12} \text{ ft. per min.}$$

Draft between drawing roller and feed roller $= \frac{Z}{Y} = R$

Draft Constant $= \frac{m \times 3{\cdot}14}{G} \times \frac{D}{I} \times \frac{E}{E_1} \times \frac{F}{l \times 3{\cdot}14} = X$

Draft $= \frac{\text{Draft constant}}{\text{Change pinion}} = \frac{X}{D_1} = R$

Example

Driving shaft speed	...	...	147 r. p. m.
Diameter of drum	...	...	28 inches
Diameter of pulley	...	...	23·5 „

Diameter of cylinder	...	49·75	inches
Cylinder pinion (to feed roller)	...	54	teeth
Double intermediate (change)	...	64/32	,,
Double intermediate		130/18/18	,,
Feed roller wheel	...	110	,,
Diameter of feed roller	...	11·75	inches
Cylinder pinion (to drawing roller)		54	teeth
Drawing roller wheel	...	50	,,
Diameter of drawing roller	...	3·875	inches
Pinion on off end of drawing roller (to doffer)		24	teeth
Double intermediate	...	54/32	,,
Doffer wheel	...	102	,,
Diameter of doffer	...	17·25	inches
Cylinder pinion (to worker)	...	54	teeth
Double intermediate	...	130/60	,,
1st. worker wheel	...	124	,,
Diameter of worker	...	9·5	inches
Diameter of stripper-driving pulley	...	20	,,
Diameter of stripper pulley	...	24	,,
Diameter of stripper	...	13·25	,,

Cylinder speed :

$$147 \times \frac{28}{23 \cdot 5} = 175 \cdot 15 \text{ r. p. m.}$$

$$175 \cdot 15 \times \frac{49 \cdot 75 \times 3 \cdot 14}{12} = 2280 \cdot 08 \text{ f. p. m.}$$

Feed roller speed :

$$175 \cdot 15 \times \frac{54}{64} \times \frac{32}{130} \times \frac{18}{110} = 5 \cdot 95 \text{ r. p. m.}$$

$$5 \cdot 95 \times \frac{11 \cdot 75 \times 3 \cdot 14}{12} = 18 \cdot 29 \text{ f. p. m.}$$

Stripper speed :

$$175{\cdot}15 \times \frac{20}{24} = 145{\cdot}96 \text{ r. p. m.}$$

$$145{\cdot}96 \times \frac{13{\cdot}25 \times 3{\cdot}14}{12} = 506{\cdot}05 \text{ f. p. m.}$$

Worker speed :

$$175{\cdot}15 \times \frac{54}{130} \times \frac{60}{124} = 35{\cdot}2 \text{ r. p.m.}$$

$$35{\cdot}2 \times \frac{9{\cdot}5 \times 3{\cdot}14}{12} = 87{\cdot}5 \text{ f. p. m.}$$

Drawing roller speed :

$$175{\cdot}15 \times \frac{54}{50} = 189{\cdot}16 \text{ r. p. m.}$$

$$189{\cdot}16 \times \frac{3{\cdot}875 \times 3{\cdot}14}{12} = 191{\cdot}80 \text{ f. p. m.}$$

Doffer speed :

$$189{\cdot}16 \times \frac{24}{54} \times \frac{32}{102} = 26{\cdot}38 \text{ r. p. m.}$$

$$26{\cdot}38 \times \frac{17{\cdot}25 \times 3{\cdot}14}{12} = 119{\cdot}07 \text{ f. p. m.}$$

Draft between drawing roller and feed roller

$$= \frac{191{\cdot}80}{18{\cdot}29} = 10{\cdot}48$$

Draft Constant

$$= \frac{3{\cdot}875 \times 3{\cdot}14}{50} \times \frac{64}{1} \times \frac{130}{18} \times \frac{110}{11{\cdot}75 \times 3{\cdot}14}$$

$$= 335{\cdot}36$$

Draft $= \dfrac{335{\cdot}36}{32} = 10{\cdot}48.$

The Dust Shaker

During the process of making jute yarn and fabric, some waste (droppings) is made. The fibre is recovered from the waste in the Dust Shaker. The droppings are fed on the feed cloth of the dust shaker. The feed cloth conveys the waste material to a pair of fluted rollers. Then the material drops into a hopper and is taken up by the pins, arranged spirally on longitudinal flat bars, fixed on rings round the central shaft. The pins open out the waste material which is conveyed to the delivery end. During the process, most of the dust and other undesirable matter drop through a grid on a travelling sheet and finally received in a separate place. The dust is sent to the boiler house to be used as fuel. The clean caddis from the delivery end of the machine, is mixed up with cuttings, jute rejections etc. and then teased in the waste teaser to make a tow for sacking weft yarn. The rotating cylinder with pins are suitably covered for better action of the pins on the waste and to prevent scattering of dust. The drum on the driving shaft drives the pulleys on the cylinder shaft.

Driving shaft speed	...	A r. p. m.
Diameter of drum	...	b inches
Diameter of pulley	...	c ,,

$$\text{Cylinder speed} = A - \frac{b}{c} \text{ r. p. m.}$$

Example

Driving shaft speed	...	147 r. p. m.
Diameter of drum	...	20 inches
Diameter of pulley	...	16 ,,

$$\text{Cylinder speed} = 147 \times \frac{20}{16} = 183{\cdot}75 \text{ r. p. m.}$$

Problems

(i) A sample of raw jute weighing 120 lbs. is dried in a conditioning oven. The dry weight is 105 lbs. Find the moisture content and the moisture regain.

Moisture in the sample $= 120 - 105 = 15$ lbs.

Moisture content $= \frac{15}{120} \times 100 = 12{\cdot}5\%$

Moisture regain $= \frac{15}{105} \times 100 = 14{\cdot}29\%$.

(ii) A batching emulsion contains 1% clensel, 24% oil and 75% water. What should be the mixture for 400 gallons of batching emulsion ?

$400 \times \frac{1}{100} = 4$ gallons clensel

$400 \times \frac{24}{100} = 96$,, oil

$400 \times \frac{75}{100} = 300$,, water.

(iii) A batching emulsion is composed of 1 gallon clensel, 20 gallons oil and 79 gallons water. 25% of this emulsion is applied to jute. Find the percentage of oil applied to jute.

Oil in emulsion $= 20\%$

25% emulsion applied to jute.

$25 \times \frac{20}{100} = 5\%$ oil applied to jute.

(iv) In a jute mill, 40000 mds. of jute was issued in a month. The quantity of recovered fibre (clean caddis) from the dust shaker for the month was 1200 mds. The quantity of dust sent to the boiler house for the same

period was 2800 mds. Find the percentage of fibre recovered and dust burnt on jute issue.

$$\text{Recovered fibre} = \frac{1200}{40000} \times 100 = 3\%$$

$$\text{Dust burnt} = \frac{2800}{40000} \times 100 = 7\%.$$

(v) In a batching department, total jute issue for one week was 6500 mds. The issue of bale cuttings was 1500 mds. 30% moisture was applied to long jute. The quantity of cuttings received from the knife line was 550 mds. for the week. Find the percentage of line cuttings.

Actual issue of long jute = 6500 − 1500 = 5000 mds.

Total cuttings received from the knife line = 550 mds.

Total dry cuttings (deducting 30% for moisture)

$$= 550 \times \frac{70}{100} = 385 \text{ mds.}$$

$$\text{Line cuttings} = \frac{385}{5000} \times 100 = 7{\cdot}7\%.$$

CHAPTER IV
THE BREAKER CARD

Carding

The operation of carding converts the long strips of jute into a continuous ribbon of fibres, loosely held together by surface irregularities. The ribbon is known as Sliver. In this process the fibres are straightened and parallelised. This also helps the blending of different qualities and colours of jute in the batch. Dirt, leaves, sticks and very short fibres are removed during the process. The first machine in the carding process is the Breaker Card.

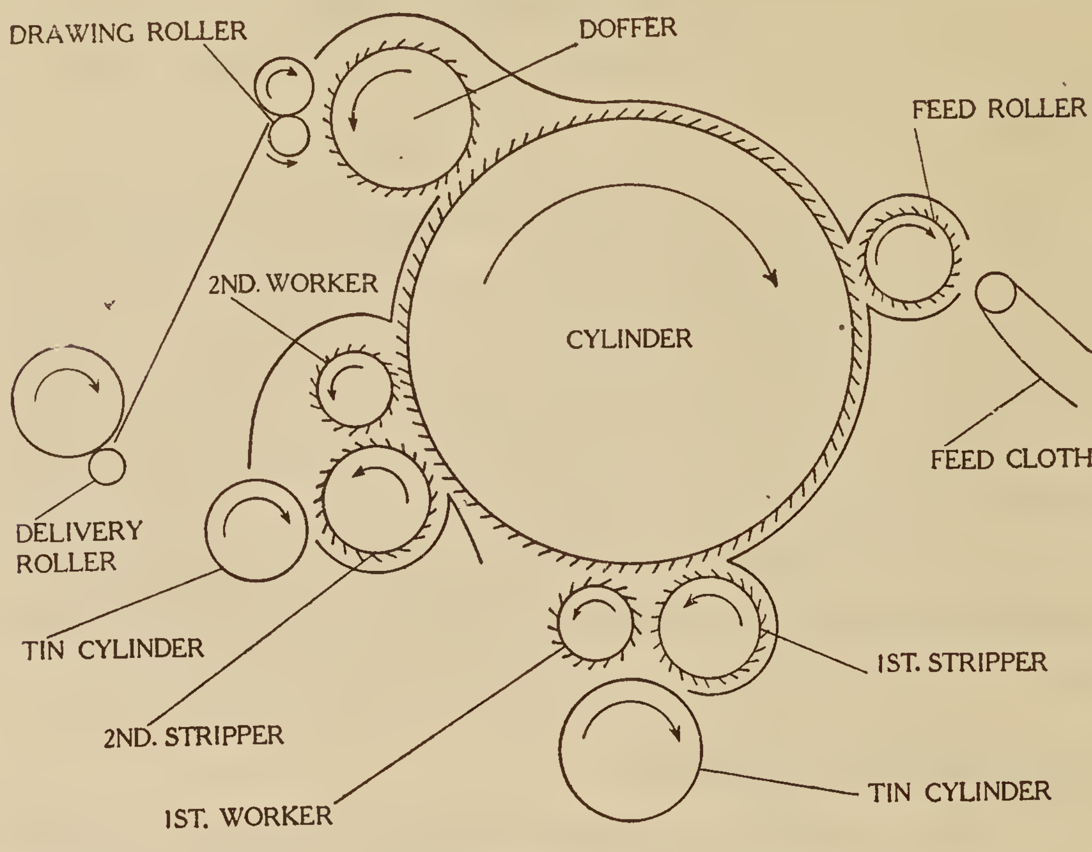
Dollop and Clock Length

A fixed quantity of jute, weighed in a scale, is spread on the feed cloth of the breaker card for a definite length of travel of the surface of the feed roller. The pointer of a clock, driven from the feed roller by gearing, indicates the travel of the surface of the feed roller. Thus a sliver of definite weight per unit length is produced. The fixed quantity of jute in weight is known as Dollop Weight. When the pointer of the clock makes one complete revolution, the surface of the feed roller of the breaker card travels a definite distance. This definite distance is known as the Clock Length of the breaker card.

Main parts of a Breaker Card

The chief parts of a breaker card are cylinder, feed roller, workers, strippers, doffer, drawing roller and

pressing roller, and delivery roller and pressing roller. All these rollers excepting the drawing and the delivery rollers



Breaker Card

are responsible for the carding action in a breaker card. The surfaces of these rollers are provided with short, sharp steel pins. These pins are set at a definite angle to the tangent of the circle for a particular roller. The usual angle of pins for different rollers are as follows :

Cylinder	...	...	71° – 75°
Feed roller	...	...	56° – 60°
Workers	...	...	32° – 38°
Strippers	...	...	36° – 40°
Doffer	...	...	32° – 38°

The pins of a roller are said to be "pointing forwards" or "Keen-set" when the pins point in the direction of rotation of the roller. The pins of a roller are said to be

"pointing backwards" or "Back-set" when the pins point in the direction opposite to that of rotation of the roller.

Cylinder	...	...	Keen-set pins
Feed roller	...	...	Back-set pins
Workers	...	...	Back-set pins
Strippers	...	...	Keen-set pins
Doffer	...	...	Back-set pins

The usual surface speeds of different rollers of a breaker card are as follows:

Cylinder	...	...	2500 ± 150	ft. per min.
Feed roller	...	...	18 ± 2	,,
Workers	...	...	48 ± 8	,,
Strippers	...	...	390 ± 90	,,
Doffer	..	...	100 ± 20	,,
Drawing roller	...	...	200 ± 20	,,

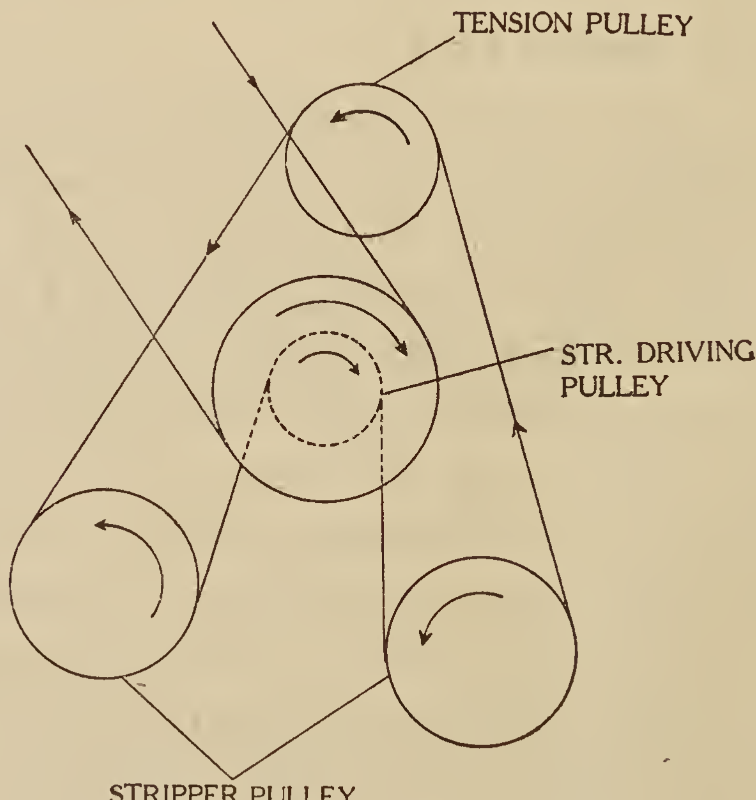
Action of the Breaker Card

As the stricks of jute are uniformly spread on the feed cloth of a breaker card, these stricks are carried and fed into the card between the back-set pins of the feed roller and the shell. The close setting of the shell to the points of the pins of the feed roller, causes the jute to be crushed into the pins of the feed roller and carried forward until it comes in contact with the pins of the cylinder. The keen-set pins of the fast-moving cylinder comb out and split up the fibre which is carried away on the pins of the cylinder. The back-set pins of the slow-running worker arrest the loosely held fibres and comb out the rest as it is carried quickly past by the cylinder. The portion retained by the worker is carried round by it and is ultimately removed from it by the keen-set pins of the faster-moving

stripper. The stripper carries the fibre again into the pins of the still-faster moving cylinder. The tin cylinder helps the worker to carry the fibre towards the stripper and to reduce the waste. The same action is repeated at the second pair of worker and stripper. The carded fibre is removed from the cylinder by the back-set pins of the doffer which in turn is cleaned by the drawing and pressing rollers. The fibre emerges from these rollers in the form of a thin, broad fleece which is condensed into a thick and narrow sliver as it passes down the conductor and finally passes out of the card through the delivery rollers. The sliver is then received in a sliver can or made into roll in a roll-former.

Breaker Card Gearing—Speed Calculations

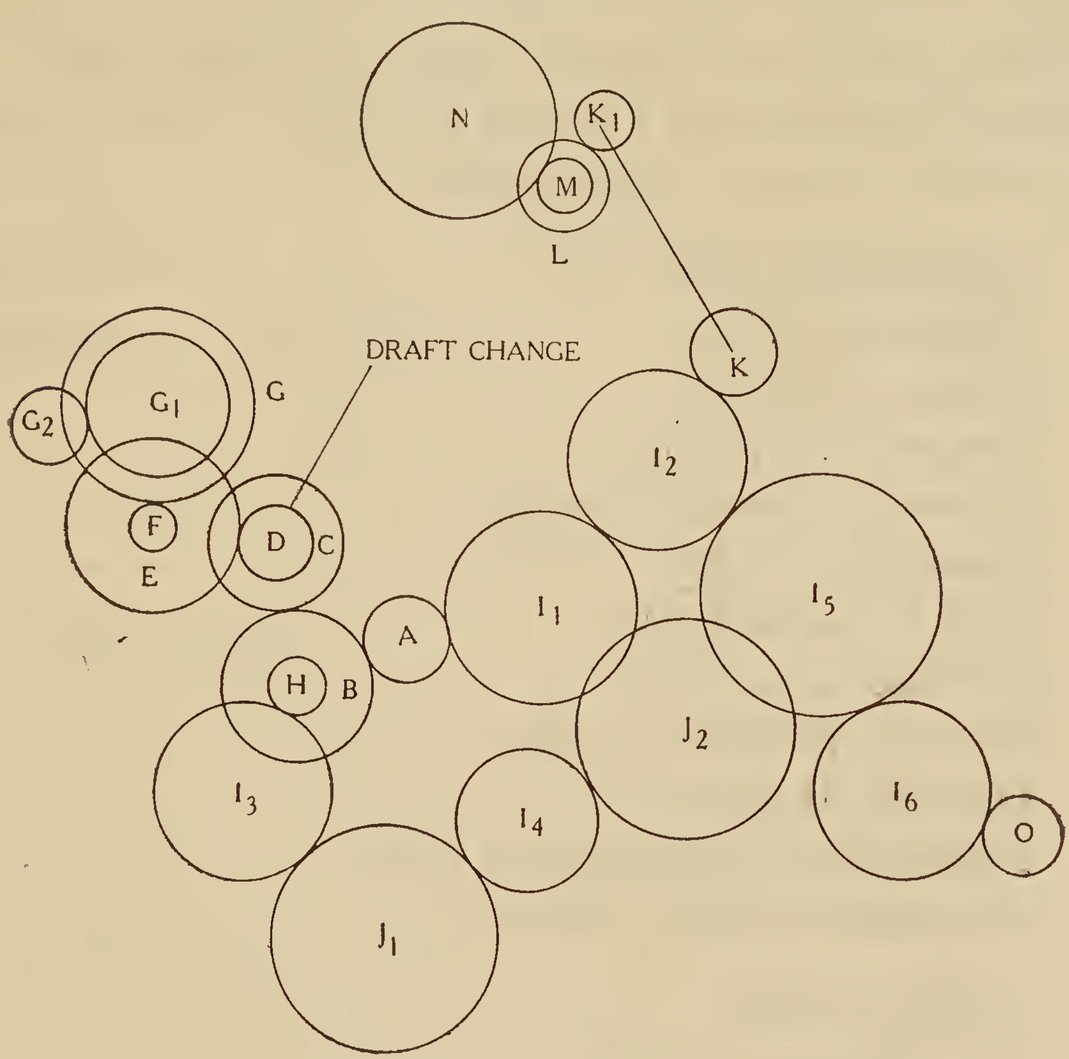
In a breaker card (Fairbairn) the drum on the driving



Breaker Card—Stripper Drive

shaft, drives the fast and loose pulleys fixed to the cylinder

arbor through belting. The stripper-driving pulley on the same arbor behind the driving pulleys, drives the stripper pulleys by another belt-drive. The pinion fixed to the arbor of the cylinder, drives the feed roller, drawing roller



Breaker Card Gearing

and worker by three distinct trains of gearing. The cylinder pinion A drives the feed roller wheel G through a single intermediate B and two double intermediates C/D and E/F. The inner pinion of the feed roller shaft G_1 drives the cloth roller wheel G_2. The cylinder pinion A, again, drives the drawing roller wheel K through two single intermediates I_1 and I_2. The pinion K_1 on

the other end of the drawing roller, drives the doffer wheel N through a double intermediate L/M. The drawing roller wheel K drives the delivery roller wheel O through three single intermediates I_2, I_5 and I_6. The cylinder pinion A, also, drives the first worker wheel J_1 through a double intermediate B/H and one single intermediate I_3. The first worker wheel J_1 drives the second worker wheel J_2 through a single intermediate I_4.

Driving shaft speed	...	... P r.p.m
Diameter of drum	...	... q inches
Diameter of pulley	...	... r ,,
Diameter of cylinder	...	... s ,,
Diameter of drawing roller	...	... t ,,
Diameter of doffer	...	... u ,,
Diameter of feed roller	...	... v ,,
Diameter of worker	...	... w ,,
Diameter of delivery roller	...	... x ,,
Diameter of stripper	...	... y ,,
Diameter of stripper-driving pulley		... z_1 ,,
Diameter of stripper pulley	...	... z_2 ,,

Cylinder speed :

$$P \times \frac{q}{r} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{s \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Feed roller speed :

$$P \times \frac{q}{r} \times \frac{A}{C} \times \frac{D}{E} \times \frac{F}{G} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{C} \times \frac{D}{E} \times \frac{F_1}{G} \times \frac{v \times 3{\cdot}14}{12} = c \text{ f. p. m.}$$

Stripper speed :

$$P \times \frac{q}{r} \times \frac{z_1}{z_2} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{z_1}{z_2} \times \frac{y \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Worker speed :

$$P \times \frac{q}{r} \times \frac{A}{B} \times \frac{H}{J_1} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{B} \times \frac{H}{J_1} \times \frac{w \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Drawing roller speed :

$$P \times \frac{q}{r} \times \frac{A}{K} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{t \times 3{\cdot}14}{12} = g \text{ f. p. m.}$$

Doffer speed :

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K_1}{L} \times \frac{M}{N} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K_1}{L} \times \frac{M}{N} \times \frac{u \times 3{\cdot}14}{12} = i \text{ f. p. m.}$$

Delivery roller speed :

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K}{O} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K}{O} \times \frac{x \times 3{\cdot}14}{12} = k \text{ f. p. m.}$$

Draft between drawing roller and feed roller $= \frac{g}{c} = R$

Draft Constant $= \frac{t \times 3{\cdot}14}{K} \times \frac{C}{1} \times \frac{E}{F} \times \frac{G}{v \times 3{\cdot}14} = X$

Draft $= \frac{\text{Draft Constant}}{\text{Change pinion}} = \frac{X}{D} = R$

Speed Ratio between drawing roller and doffer :

$$\frac{g}{i}=S$$

$$\frac{t\times 3{\cdot}14}{K_1}\times\frac{L}{M}\times\frac{N}{u\times 3{\cdot}14}=S$$

Speed Ratio between delivery roller and drawing roller :

$$\frac{k}{g}=T$$

$$\frac{x\times 3{\cdot}14}{O}\times\frac{K}{t\times 3{\cdot}14}=T.$$

Example

Driving shaft speed	...	285 r.p.m.
Diameter of drum	...	19 inches
Diameter of pulley	...	30 ,,
Diameter of cylinder	...	49·75 ,,
Cylinder pinion (to feed roller)	...	60 teeth
Double intermediate	...	96/34 ,, (change)
Double intermediate	...	130/24 ,,
Feed roller wheel	...	130 ,,
Diameter of feed roller	...	11·5 inches
Cylinder pinion (to drawing roller)		60 teeth
Drawing roller wheel	...	56 ,,
Diameter of drawing roller	...	4 inches
Pinion on off end of drawing roller (to doffer)		24 teeth
Double intermediate	...	56/28 ,,
Doffer wheel	...	104 ,,
Diameter of doffer	...	17 inches
Cylinder pinion (to worker)	...	60 teeth
Double intermediate	...	130/25 ,,

First worker wheel ...	124	teeth
Second worker wheel ...	124	,,
Diameter of workers ...	9·25	inches
Drawing roller wheel (to delivery roller)	56	teeth
Delivery roller wheel ...	68	,,
Diameter of delivery roller ...	5	inches
Diameter of stripper-driving pulley	14	,,
Diameter of stripper pulley ...	20	,,
Diameter of stripper ...	13	,,

Cylinder speed :

$$285 \times \frac{19}{30} = 180{\cdot}5 \text{ r. p. m.}$$

$$180{\cdot}5 \times \frac{49{\cdot}75 \times 3{\cdot}14}{12} = 2349{\cdot}73 \text{ f. p. m.}$$

Feed roller speed :

$$180{\cdot}5 \times \frac{60}{96} \times \frac{34}{130} \times \frac{24}{130} = 5{\cdot}45 \text{ r. p. m.}$$

$$5{\cdot}45 \times \frac{11{\cdot}5 \times 3{\cdot}14}{12} = 16{\cdot}40 \text{ f. p. m.}$$

Stripper speed :

$$180{\cdot}5 \times \frac{14}{20} = 126{\cdot}35 \text{ r. p. m.}$$

$$126{\cdot}35 \times \frac{13 \times 3{\cdot}14}{12} = 429{\cdot}80 \text{ f. p. m.}$$

Worker speed :

$$180{\cdot}5 \times \frac{60}{130} \times \frac{25}{124} = 16{\cdot}80 \text{ r. p. m.}$$

$$16{\cdot}80 \times \frac{9{\cdot}25 \times 3{\cdot}14}{12} = 40{\cdot}66 \text{ f. p. m.}$$

Drawing roller speed :

$$180{\cdot}5 \times \frac{60}{56} = 193{\cdot}39 \text{ r. p. m.}$$

$$193{\cdot}39 \times \frac{4 \times 3{\cdot}14}{12} = 202{\cdot}41 \text{ f. p. m.}$$

Doffer speed :

$$193{\cdot}39 \times \frac{24}{56} \times \frac{28}{104} = 22{\cdot}31 \text{ r. p. m.}$$

$$22{\cdot}31 \times \frac{17 \times 3{\cdot}14}{12} = 99{\cdot}24 \text{ f. p. m.}$$

Delivery roller speed :

$$193{\cdot}39 \times \frac{56}{68} = 159{\cdot}24 \text{ r. p. m.}$$

$$159{\cdot}24 \times \frac{5 \times 3{\cdot}14}{12} = 208{\cdot}34 \text{ f. p. m.}$$

Draft between drawing roller and feed roller

$$= \frac{202{\cdot}41}{16{\cdot}40} = 12{\cdot}34$$

Draft Constant

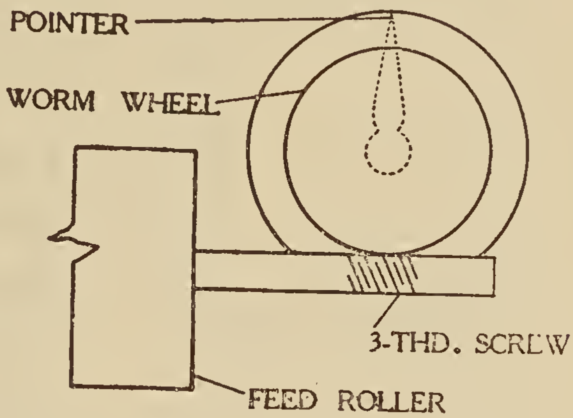
$$= \frac{4 \times 3{\cdot}14}{56} \times \frac{96}{1} \times \frac{130}{24} \times \frac{130}{11{\cdot}5 \times 3{\cdot}14} = 419{\cdot}87$$

$$\text{Draft} = \frac{419{\cdot}87}{34} = 12{\cdot}34$$

Breaker Card — Clock Length

In a breaker card (Fairbairn), the clock is connected to the feed roller in the following way. One three-threaded screw on the feed roller arbor drives a worm wheel of 42

teeth. The worm wheel is fixed to the same spindle as the pointer of the clock. When the pointer of the clock makes one complete revolution the feed roller makes $\frac{42}{3} = 14$ revolutions. Clock length is the length traversed by the surface of the feed roller when the pointer of the clock makes one complete revolution. The diameter of the feed roller is 10·75 inches.



Clock Gearing

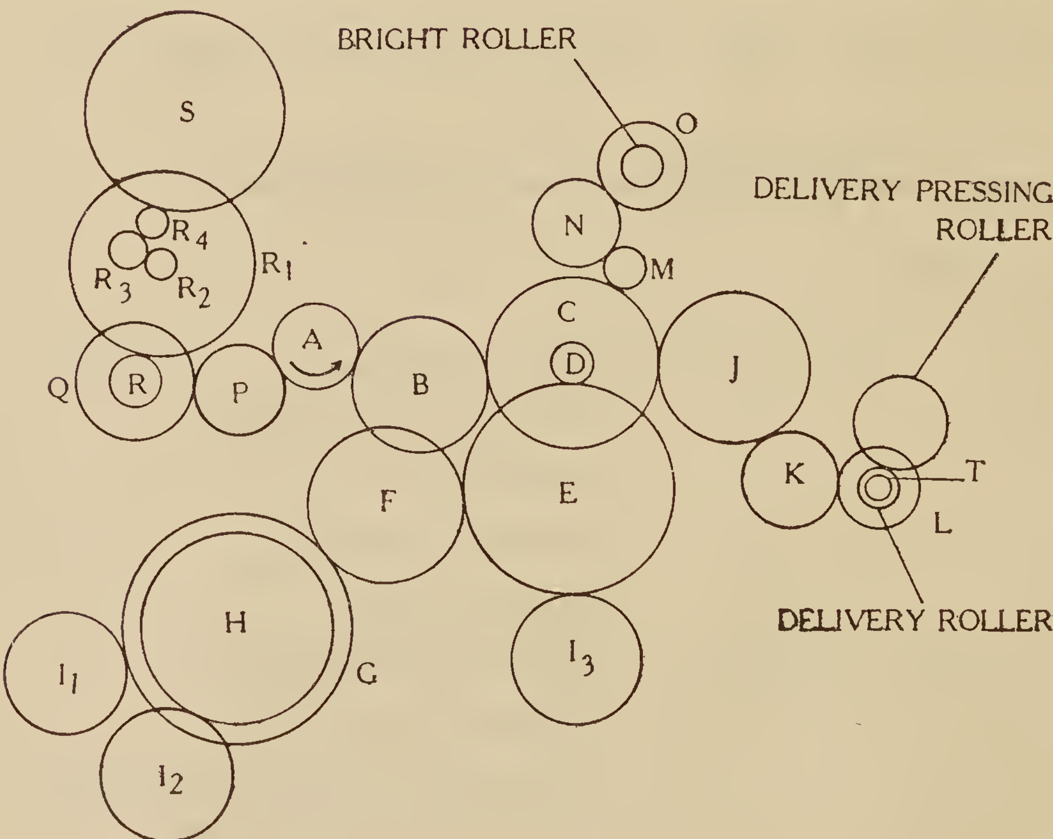
$$\text{Clock length} = \frac{42}{3} \times \frac{10{\cdot}75 \times 3{\cdot}14}{36} = 13{\cdot}13 \text{ yards.}$$

Breaker Card (Mackie) Gearing—Calculations

Gearing Side

A	...	Cylinder changes
B	...	Cylinder intermediate
C	...	Worker D. C.
D	...	Worker changes
E	...	Worker wheel
F	...	Worker intermediate
G	...	Worker wheel D. C.
H	...	Wheel on worker D. C.
I_1	...	1st. tin cylinder wheel
I_2	...	2nd. tin cylinder wheel
I_3	...	3rd. tin cylinder wheel
J	...	Intermediate driving delivery
K	...	Delivery intermediate
L	...	Delivery wheel

M	...	Bright roller intermediate (double)
N	...	Bright roller intermediate
O	...	Bright roller wheel
P	...	Feed intermediate
Q	...	Feed D. C.
R	...	Feed changes
R_1	...	Reversing stud wheel
R_2	...	Reversing stud pinion
R_3, R_4	...	Reversing intermediate
S	...	Feed wheel
T	...	Chain wheel on delivery roller

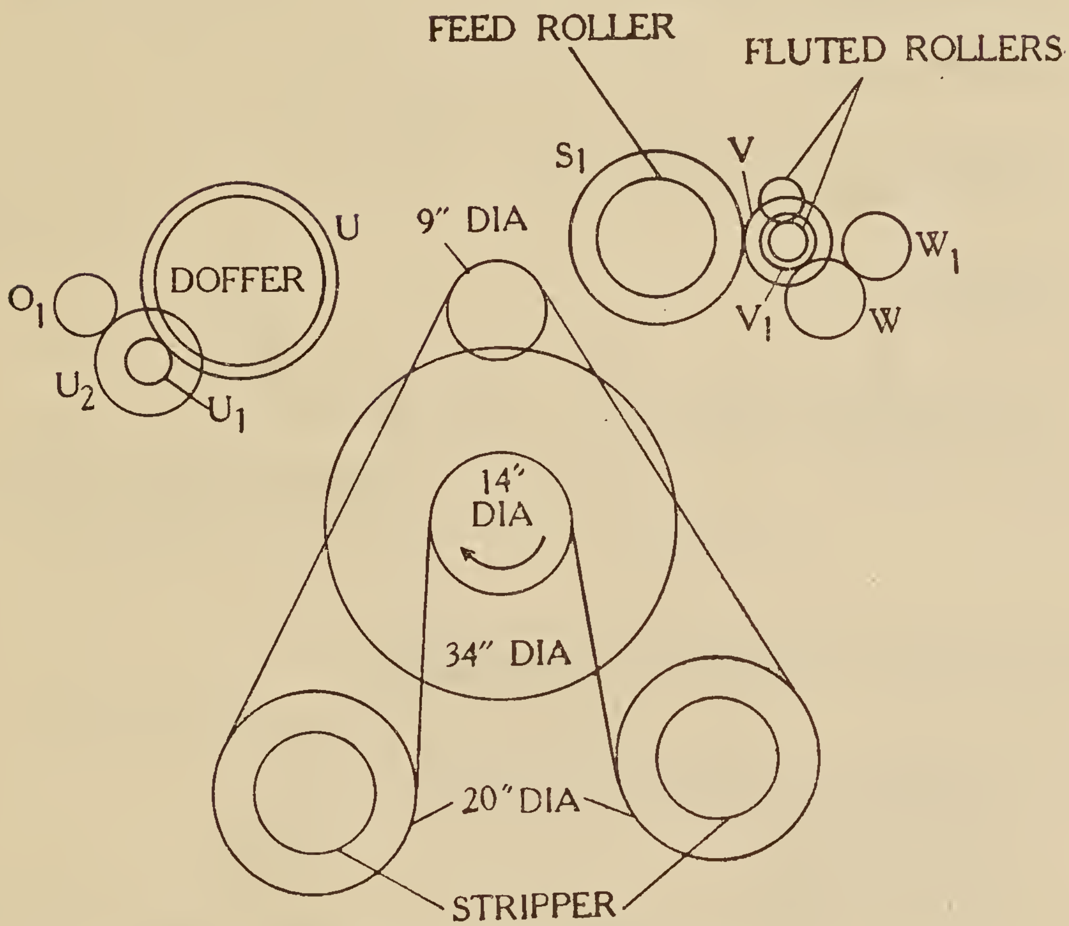


Breaker Card (Mackie) Gearing
Gearing side

Pulley Side

U	...	Doffer wheel
U_1	...	Doffer D. C. pinion

U_2	...	Doffer D. C.
O_1	...	Bright roller pinion
S_1	...	Feed wheel driving fluted roller
V	...	Fluted roller wheel
V_1	...	Fluted roller pinion
W	...	Sheet intermediate
W_1	...	Sheet roller wheel



Breaker Card (Mackie) Gearing
Pulley side

Delivery speed :

$$\text{cylinder r. p. m.} \times \frac{A}{L} \times \frac{\text{delivery roller dia.} \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Feed ratio :

$$\frac{1}{\text{feed roller dia.}} \times \frac{S}{R_2} \times \frac{R_1}{R} \times \frac{Q}{A} \times \frac{\text{cylinder dia.}}{1}$$

Stripper ratio :

$$\frac{1}{\text{stripper dia.}} \times \frac{\text{stripper pulley dia.}}{\text{stripper driving pulley dia.}} \times \frac{\text{cylinder dia.}}{1}$$

Worker ratio :

$$\frac{1}{\text{worker dia.}} \times \frac{E}{D} \times \frac{C}{A} \times \frac{\text{cylinder dia.}}{1}$$

Doffer ratio :

$$\frac{1}{\text{doffer dia.}} \times \frac{U}{U_1} \times \frac{U_2}{O_1} \times \frac{O}{A} \times \frac{\text{cylinder dia.}}{1}$$

Draft :

$$\frac{1}{\text{fluted roller circum.}} \times \frac{V}{S_1} \times \frac{S}{R_2} \times \frac{R_1}{R} \times \frac{Q}{L} \times \frac{\text{delivery roller circum.}}{1}$$

Breaker Card—Production Calculations

(i) Weight per 100 yds. of delivery :

Clock length ... L yds.
Dollop weight ... W lbs.
Draft of breaker card ... D

Weight of breaker feed per yd. $= \frac{W}{L}$ lbs.

Weight of breaker feed per 100 yds. $= \frac{W \times 100}{L}$ lbs.

Weight of breaker delivery per 100 yds.

$$= \frac{W \times 100}{L \times D} = W_1 \text{ lbs.}$$

(ii) Production per day of x hours :

Surface speed of drawing roller ... S f. p. m.

Breaker delivery per hour $= \frac{S \times 60}{3}$ yds.

Weight of breaker delivery per hour $= \frac{S \times 60 \times W_1}{3 \times 100}$ lbs.

Production of breaker card per day of x hours

$$= \frac{S \times 60 \times W_1 \times x}{3 \times 100} \text{ lbs.}$$

Example

Clock length ...	...	12·3 yds.
Dollop weight ...	...	20 lbs.
Draft on breaker card	...	10·82
Surface speed of drawing roller	...	210 f. p. m.

Weight of breaker delivery per 100 yds.

$$= \frac{20 \times 100}{12{\cdot}3 \times 10{\cdot}82} = 15{\cdot}03 \text{ lbs.}$$

Production per day of 10 hours

$$= \frac{210 \times 60 \times 15{\cdot}03 \times 10}{3 \times 100} = 6312{\cdot}60 \text{ lbs.}$$

Roll-Forming

The sliver from the breaker card is usually made into roll in a roll-former. A sliver roll-former (Fraser) mainly consists of two aluminium forming discs with brass bosses, one roll driver and a pair of disc driving rollers. The cork-covered roll driver and the leather-covered disc driving rollers are driven from the delivery roller of the breaker card through gearing. A sprocket pinion on the

delivery roller arbor, drives the roll driver wheel through a double intermediate consisting of a sprocket wheel and a spur wheel and another double intermediate. The sprocket pinion on the delivery roller arbor, again, drives the disc driving roller sprocket wheel through a double intermediate consisting of chain sprocket wheels. The forming discs normally rest on the disc driving rollers and move in contact with them. When a quantity of sliver is made into a small roll round the forming disc arbor sleeves the forming discs are raised from the disc driving rollers and rotate in contact with the roll driver. When the roll of sliver reaches a predetermined diameter, the forming discs open and the roll of sliver being free of the bosses, comes out.

Breaker card delivery roller speed	...	R r. p. m.
Sprocket pinion on delivery roller arbor (to roll driver)	...	A teeth
Double intermediate	...	C/D ,,
Double intermediate	...	E/F ,,
Roll driver wheel	...	B ,,
Diameter of roll driver	...	b inches
Sprocket pinion on delivery roller arbor (to disc driving roller)	...	A teeth
Double intermediate	...	C/G ,,
Disc driving roller sprocket wheel	...	H ,,
Diameter of disc driving roller	...	h inches

Roll driver speed :

$$R \times \frac{A}{C} \times \frac{D}{E} \times \frac{F}{B} \text{ r. p. m.}$$

$$R \times \frac{A}{C} \times \frac{D}{E} \times \frac{F}{B} \times \frac{b \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Disc driving roller speed :

$$R \times \frac{A}{C} \times \frac{G}{H} \text{ r. p. m.}$$

$$R \times \frac{A}{C} \times \frac{G}{H} \times \frac{h \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Example

Breaker card delivery roller speed	... 152·35	r. p. m.
Sprocket pinion on delivery roller arbor (to roll driver)	... 24	teeth
Double intermediate	... 23/33	,,
Double intermediate	... 70/28	,,
Roll driver wheel	... 60	,,
Sprocket pinion on delivery roller arbor (to disc driving roller)	24	,,
Double intermediate	... 23/56	,,
Disc driving roller sprocket wheel	... 16	,,
Diameter of roll driver	... 22·875	inches
Diameter of disc driving roller	.. 8·75	,,
Diameter of delivery roller	... 5	,,

Roll driver speed :

$$152{\cdot}35 \times \frac{24}{23} \times \frac{33}{70} \times \frac{28}{60} = 33{\cdot}73 \text{ r. p. m.}$$

$$33{\cdot}73 \times \frac{22{\cdot}875 \times 3{\cdot}14}{12} = 201{\cdot}90 \text{ f. p. m.}$$

Disc driving roller speed :

$$152{\cdot}35 \times \frac{24}{23} \times \frac{56}{16} = 556{\cdot}41 \text{ r. p. m.}$$

$$556{\cdot}41 \times \frac{8{\cdot}75 \times 3{\cdot}14}{12} = 1273{\cdot}95 \text{ f. p. m.}$$

Breaker card delivery roller speed :

$$152{\cdot}35 \times \frac{5 \times 3{\cdot}14}{12} = 199{\cdot}32 \text{ f. p. m.}$$

Lead of roll driver over delivery roller :

$$\frac{(201{\cdot}90 - 199{\cdot}32) \times 100}{199{\cdot}32} = 1{\cdot}29\%$$

An autocoyl (Port Engineering) essentially consists of an intake roller with a pressing roller, two aluminium discs with brass pick-ups and a pressure wheel. The toothed pick-ups rotate in contact with the pressure wheel and as the sliver is formed into a roll round the pick-ups, the roll moves in contact with it. When the roll reaches a definite size, a lever arrangement causes the pick-ups to move apart. The roll of sliver being free of the pick-ups, comes out as the discs also open a bit at the same time to release the roll.

Problems

(i) The draft and clock length of a breaker card are 12·5 and 13·13 yds. respectively. What would be the dollop to produce a delivery of 15 lbs. per 100 yds. ?

$$\frac{\text{Dollop} \times 100}{13{\cdot}13 \times 12{\cdot}5} = 15 \text{ lbs.}$$

$$\text{Dollop} = \frac{13{\cdot}13 \times 12{\cdot}5 \times 15}{100} = 24{\cdot}62 \text{ lbs.}$$

(ii) In a breaker card (Low), a wheel of 26 teeth on the feed roller arbor drives the worm shaft wheel of 26 teeth. A double-threaded screw drives the worm wheel of 24 teeth on the vertical shaft. The bevel pinion of 18 teeth on the other end of the vertical shaft is in gear

with another bevel pinion of 18 teeth on the clock spindle to which the pointer is attached. If the diameter of the feed roller is 11·75 inches, find the clock length.

For one revolution of the pointer, the feed roller makes

$$\frac{18}{18} \times \frac{24}{2} \times \frac{26}{26} = 12 \text{ revs.}$$

$$\text{Clock length} = \frac{12 \times 11{\cdot}75 \times 3{\cdot}14}{36} = 12{\cdot}30 \text{ yds.}$$

(iii) Find the clock length of a breaker card (Fraser) from the following data :

Bevel pinion on pointer spindle		14 teeth
Bevel pinion on vertical shaft		14 ,,
Worm wheel on vertical shaft		24 ,,
Worm ...	...	single-threaded
Worm shaft wheel	...	24 teeth
Feed roller wheel	...	48 ,,
Diameter of feed roller	...	11·5 inches

$$\text{Clock length} = \frac{14}{14} \times \frac{24}{1} \times \frac{24}{48} \times \frac{11{\cdot}5 \times 3{\cdot}14}{36} = 12{\cdot}04 \text{ yds.}$$

(iv) In a breaker card (Lawson), one double-threaded screw on the feed roller arbor drives a wheel of 60 teeth which is fixed to the same spindle as the pointer of the clock through a double intermediate 24/39 teeth and a single intermediate. If the diameter of the feed roller is 9·75 inches, find the clock length.

$$\text{Clock length} = \frac{60}{39} \times \frac{24}{2} \times \frac{9{\cdot}75 \times 3{\cdot}14}{36} = 15{\cdot}6 \text{ yds.}$$

(v) A breaker card drawing roller is 4 inches in diameter. The drawing roller makes 125 revs. per min. The sliver from the card is 20 lbs. per 100 yds. Find

the production of the breaker card per hour at 80% efficiency.

$$\text{Delivery per minute} = \frac{125 \times 4 \times 3{\cdot}14}{36} = 43{\cdot}61 \text{ yds.}$$

$$\text{Delivery per hour} = 43{\cdot}61 \times 60 \text{ yds.}$$

$$\text{Production per hour} = \frac{43{\cdot}61 \times 60 \times 20}{100} = 523{\cdot}32 \text{ lbs.}$$

Production per hr. at 80% efficiency

$$= 523{\cdot}32 \times \frac{80}{100} = 418{\cdot}66 \text{ lbs.}$$

(vi) Calculate the weight of sliver from a breaker card in lbs. per 100 yds. from the following details allowing 7% loss due to evaporation of moisture and droppings.

Dollop	...	30 lbs.
Breaker card clock length	...	12·04 yds.
" " draft	...	12

$$\frac{30 \times 100 \times 93}{12{\cdot}04 \times 12 \times 100} = 19{\cdot}31 \text{ lbs. per 100 yds.}$$

(vii) The diameter of the drawing roller of a breaker card is 4 inches. The sliver from the breaker card is 15 lbs. per 100 yds. What would be the speed of the drawing roller in revs. per min. to produce 5050 lbs. of sliver per day of 10 hours at 80% efficiency ?

$$\text{Production at 100\% efficiency} = 5050 \times \frac{100}{80} = 6312{\cdot}5 \text{ lbs.}$$

$$\frac{\text{Drawing roller f. p. m.} \times 60 \times 10 \times 15}{3 \times 100} = 6312{\cdot}5 \text{ lbs.}$$

$$\text{Drawing roller f. p. m.} = \frac{3 \times 100 \times 6312{\cdot}5}{60 \times 10 \times 15} = 210{\cdot}42$$

$$\text{Drawing roller r. p. m.} = \frac{210{\cdot}42 \times 12}{4 \times 3{\cdot}14} = 201{\cdot}06.$$

CHAPTER V

THE FINISHER CARD

Carding in a Finisher Card

The sliver from the breaker card is more or less irregular. So the carding is continued on a finer scale in a Finisher Card with more pairs of rollers and finer clothing. A fixed number of rolls of sliver from breaker cards are usually fed into the finisher card by placing them on corrugated rollers on the feed side, driven from the feed roller by suitable gearing. This "doubling of slivers" reduces the irregularity in the resultant sliver from the finisher card.

Main Parts of a Finisher Card

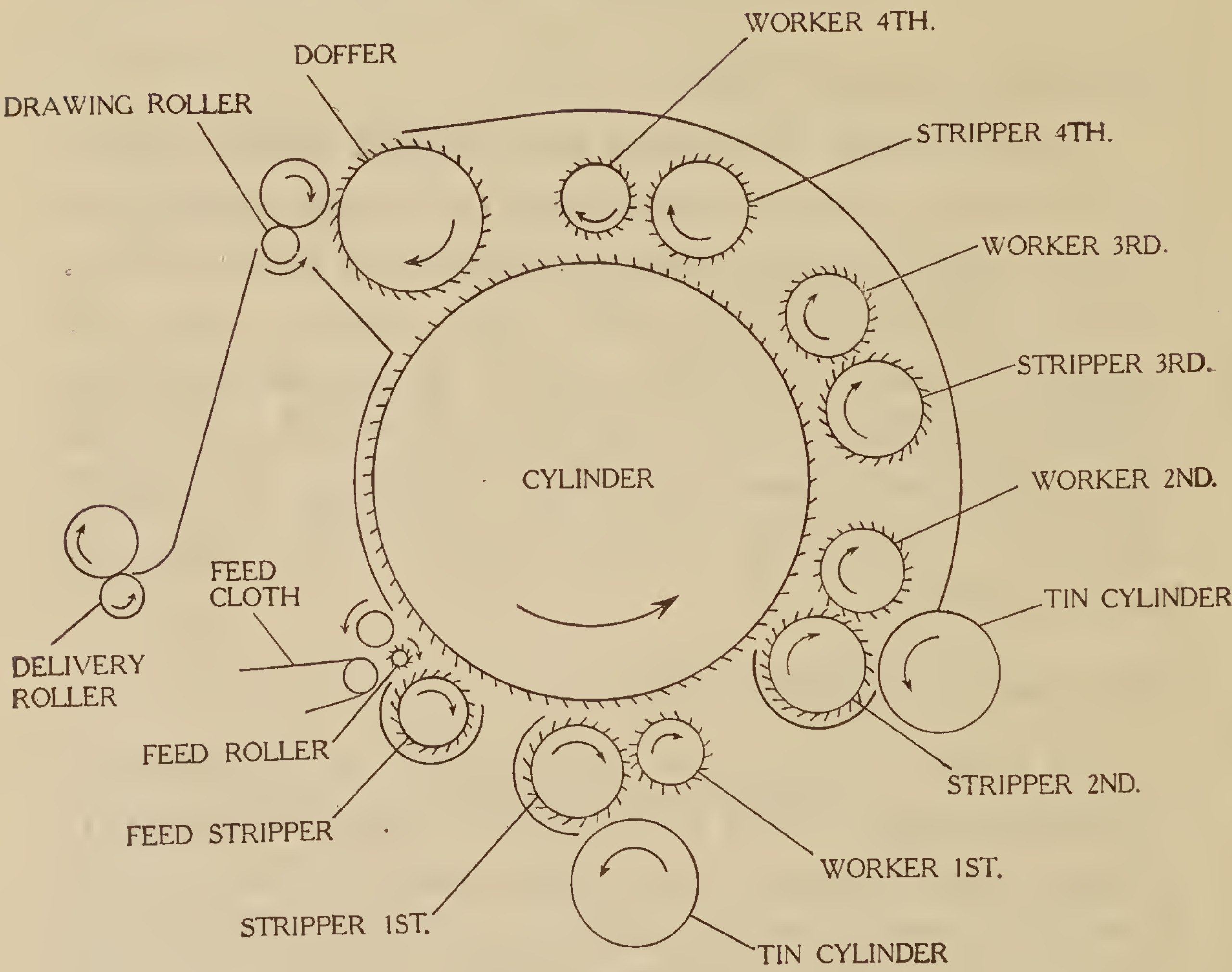
The finisher card may be half-circular or full-circular. The half-circular finisher card usually consists of three pairs of workers and strippers. In these cards, the feed and the delivery are on the opposite sides. A half-circular finisher card is very similar to a breaker card. So it is not described here.

The full-circular finisher card consists of four, five or even six pairs of rollers. In these cards, the feed and the delivery are on the same side. Also a feed stripper is used to clean the feed roller.

The usual surface speeds of different rollers are as follows :

Cylinder	...	2500 ± 150	f. p. m.
Feed roller	...	14 ± 2	,,
Workers	...	40 ± 10	,,

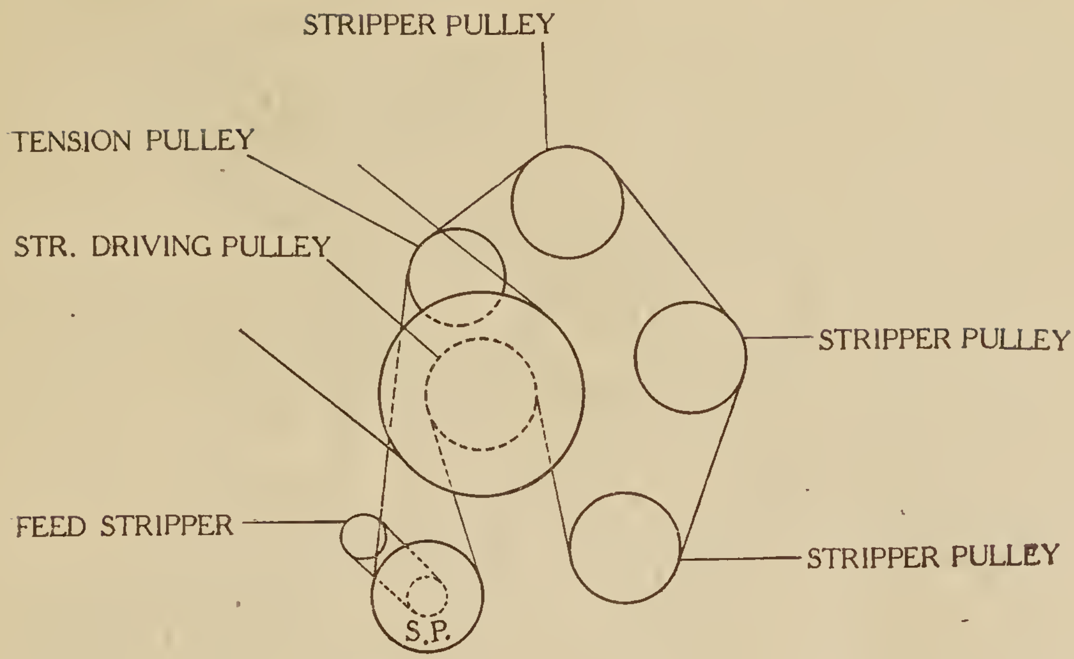
Strippers	...	450 ± 100 f. p. m.
Doffer	...	105 ± 20 ,,
Drawing roller	...	210 ± 20 ,,



The Finisher Card

Finisher Card Gearing—Speed Calculations

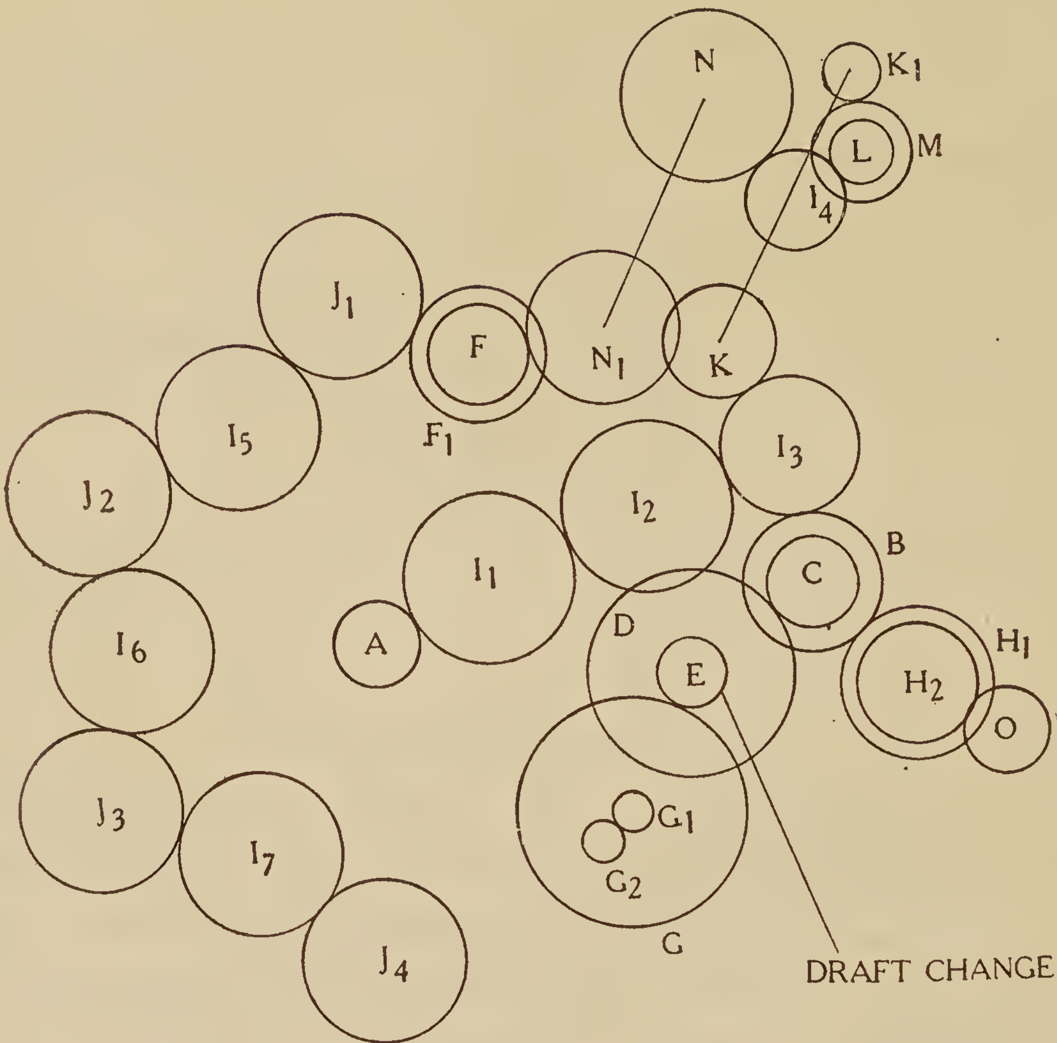
In a finisher card, the drum on the driving shaft, drives the fast and loose pulleys, fixed to the cylinder arbor through belting. The stripper-driving pulley on the same arbor behind the driving pulleys, drives the stripper pulleys by another belt-drive. The motion is conveyed to the feed stripper from the first stripper by means of sprocket wheels connected by a chain. The cylinder pinion on the cylinder



Finisher Card—Stripper Drive

arbor is the main driver. The cylinder pinion A drives the feed roller wheel G through three single intermediates I_1, I_2, I_3 and two double intermediates B/C, D/E. The drawing roller wheel K is driven from the cylinder pinion A through three single intermediates I_1, I_2 and I_3. The drawing roller wheel K drives the delivery roller wheel O through two single intermediates I_3 and B and a double intermediate H_1/H_2. The pinion K_1 on the other side of the drawing roller, drives the doffer wheel N through a double intermediate M/L and a single intermediate I_4. The wheel N_1 on the near end of the doffer, drives the first worker wheel J_1 through a double intermediate F/F_1.

This drive is continued to the second worker wheel J_2 through a single intermediate I_5. The wheel J_2, in turn drives the third worker wheel J_3 through a single intermediate I_6. The fourth worker wheel J_4 is driven from J_3 through a single intermediate I_7.



Finisher Card Gearing

Driving shaft speed	... ...	P	r. p. m.
Diameter of drum	... ...	q	inches.
Diameter of pulley	... ...	r	,,
Diameter of cylinder	... ...	s	,,
Diameter of drawing roller	... ...	t	,,
Diameter of doffer	... ...	u	,,
Diameter of feed roller	... ...	v	,,
Diameter of worker	... ...	w	,,
Diameter of delivery roller	... ...	x	,,
Diameter of stripper	... ...	y	,,
Diameter of stripper driving pulley	...	z_1	,,
Diameter of stripper pulley	... ...	z_2	,,

Cylinder speed :

$$P \times \frac{q}{r} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{s \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Feed roller speed :

$$P \times \frac{q}{r} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{G} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{G} \times \frac{v \times 3{\cdot}14}{12} = c \quad \text{f. p. m.}$$

Stripper speed :

$$P \times \frac{q}{r} \times \frac{z_1}{z_2} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{z_1}{z_2} \times \frac{y \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Drawing roller speed :

$$P \times \frac{q}{r} \times \frac{A}{K} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{t \times 3{\cdot}14}{12} = g \quad \text{f. p. m.}$$

Doffer speed :

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K_1}{M} \times \frac{L}{N} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K_1}{M} \times \frac{L}{N} \times \frac{u \times 3{\cdot}14}{12} = i \quad \text{f. p. m.}$$

Worker speed :

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K_1}{M} \times \frac{L}{N} \times \frac{N_1}{F} \times \frac{F_1}{J_1} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K_1}{M} \times \frac{L}{N} \times \frac{N_1}{F} \times \frac{F_1}{J_1} \times \frac{w \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Delivery roller speed :

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K}{H_1} \times \frac{H_2}{O} \text{ r. p. m.}$$

$$P \times \frac{q}{r} \times \frac{A}{K} \times \frac{K}{H_1} \times \frac{H_2}{O} \times \frac{x \times 3{\cdot}14}{12} = k \text{ f. p. m.}$$

Draft between drawing roller and feed roller $= \frac{g}{c} = R$

Draft Constant $= \frac{t \times 3{\cdot}14}{K} \times \frac{B}{C} \times \frac{D}{1} \times \frac{G}{v \times 3{\cdot}14} = X$

Draft $= \frac{\text{Draft constant}}{\text{Change pinion}} = \frac{X}{E} = R$

Speed Ratio between drawing roller and doffer :

$$\frac{g}{i} = S$$

$$\frac{t \times 3{\cdot}14}{K_1} \times \frac{M}{L} \times \frac{N}{u \times 3{\cdot}14} = S$$

Speed Ratio between delivery roller and drawing roller :

$$\frac{k}{g} = T$$

$$\frac{x \times 3{\cdot}14}{O} \times \frac{H_2}{H_1} \times \frac{K}{t \times 3{\cdot}14} = T$$

Example

Driving shaft speed	... ...	200 r. p. m.
Diameter of drum	... ...	30 inches
Diameter of pulley	... ...	30 ,,
Diameter of cylinder	... ...	49·75 ,,
Cylinder pinion (to feed roller)	...	60 teeth
Double intermediate	... ...	72/48 ,,
Double intermediate	... ...	116/22 ,, (change)

Feed roller wheel	118	teeth
Diameter of feed roller	4	inches
Cylinder pinion (to drawing roller) ...	60	teeth
Drawing roller wheel	60	teeth
Diameter of drawing roller	4	inches
Pinion on off end of drawing roller (to doffer)	22	teeth
Double intermediate	54/28	,,
Doffer wheel	88	,,
Diameter of doffer	16·5	inches
Pinion on off end of doffer (to worker)	80	teeth
Double intermediate	64/40	,,
Worker wheel	88	,,
Diameter of worker	9·5	inches
Drawing roller wheel (to delivery roller)	60	teeth
Double intermediate ...	80/64	,,
Delivery roller wheel	48	,,
Diameter of delivery roller	4	inches
Diameter of stripper driving pulley ...	14	,,
Diameter of stripper pulley	16	,,
Diameter of stripper	11·25	,,

Cylinder speed :

$$200 \times \frac{30}{30} = 200 \text{ r. p. m.}$$

$$200 \times \frac{49{\cdot}75 \times 3{\cdot}14}{12} = 2603{\cdot}58 \text{ f. p. m.}$$

Feed roller speed :

$$200 \times \frac{60}{72} \times \frac{48}{116} \times \frac{22}{118} = 12{\cdot}86 \text{ r. p. m.}$$

$$12{\cdot}86 \times \frac{4 \times 3{\cdot}14}{12} = 13{\cdot}46 \text{ f. p. m.}$$

Stripper speed :

$$200 \times \frac{14}{16} = 175 \text{ r. p. m.}$$

$$175 \times \frac{11{\cdot}25 \times 3{\cdot}14}{12} = 515{\cdot}16 \text{ f. p. m.}$$

Drawing roller speed :

$$200 \times \frac{60}{60} = 200 \text{ r. p. m.}$$

$$200 \times \frac{4 \times 3{\cdot}14}{12} = 209{\cdot}33 \text{ f. p. m,}$$

Doffer speed :

$$200 \times \frac{22}{54} \times \frac{28}{88} = 25{\cdot}93 \text{ r. p. m.}$$

$$25{\cdot}93 \times \frac{16{\cdot}5 \times 3{\cdot}14}{12} = 111{\cdot}95 \text{ f. p. m.}$$

Worker speed :

$$25{\cdot}93 \times \frac{80}{64} \times \frac{40}{88} = 14{\cdot}73 \text{ r. p. m.}$$

$$14{\cdot}73 \times \frac{9{\cdot}5 \times 3{\cdot}14}{12} = 36{\cdot}62 \text{ f. p. m.}$$

Delivery roller speed :

$$200 \times \frac{60}{80} \times \frac{64}{48} = 200 \text{ r. p. m.}$$

$$200 \times \frac{4 \times 3{\cdot}14}{12} = 209{\cdot}33 \text{ f. p. m.}$$

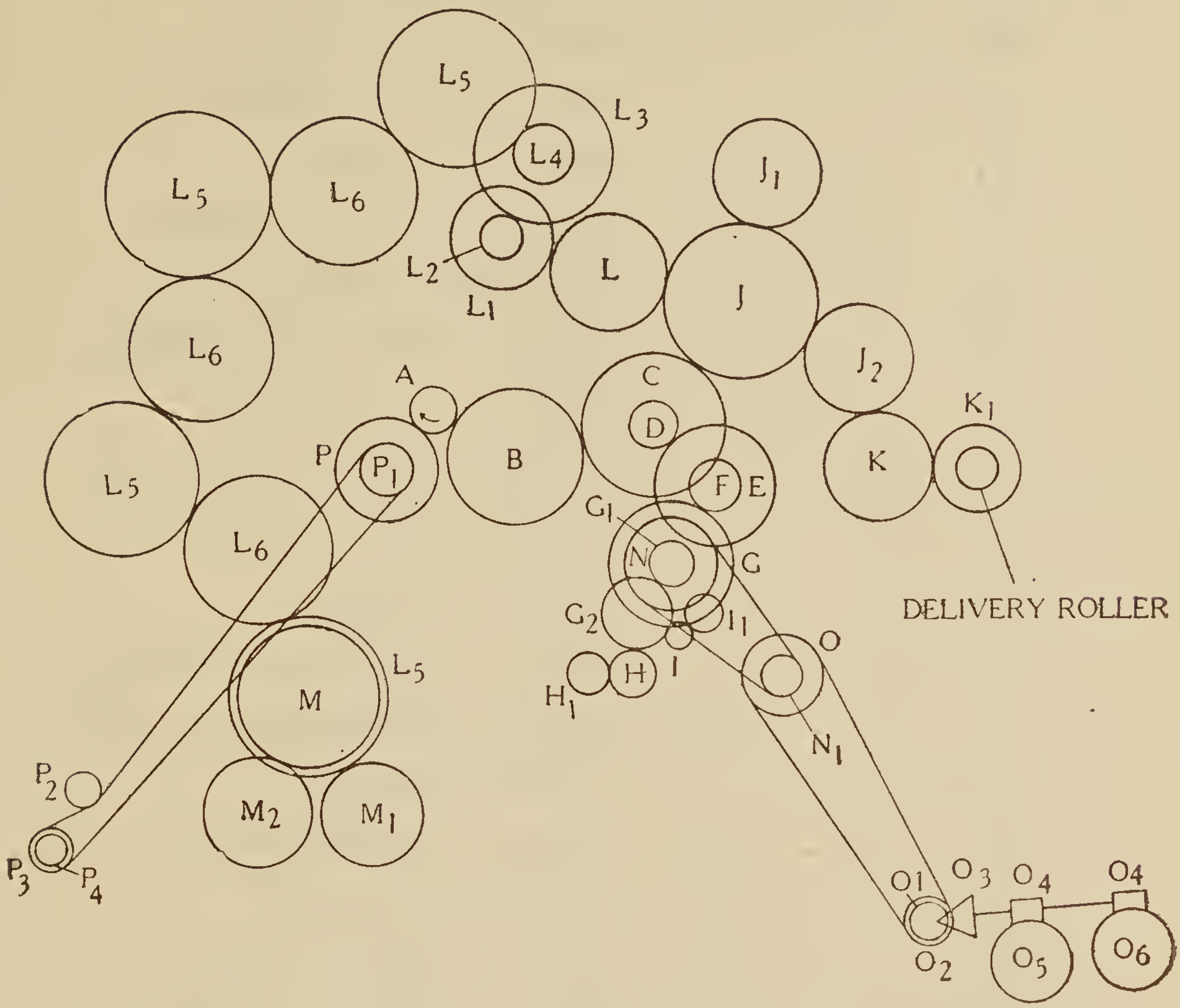
Draft between drawing roller and feed rolier

$$= \frac{209{\cdot}33}{13{\cdot}46} = 15{\cdot}55$$

$$\text{Draft Constant} = \frac{4 \times 3{\cdot}14}{60} \times \frac{72}{48} \times \frac{116}{1} \times \frac{118}{4 \times 3{\cdot}14} = 342{\cdot}20$$

$$\text{Draft} = \frac{342{\cdot}20}{22} = 15{\cdot}55$$

Finisher Card (Mackie) Gearing—Calculations



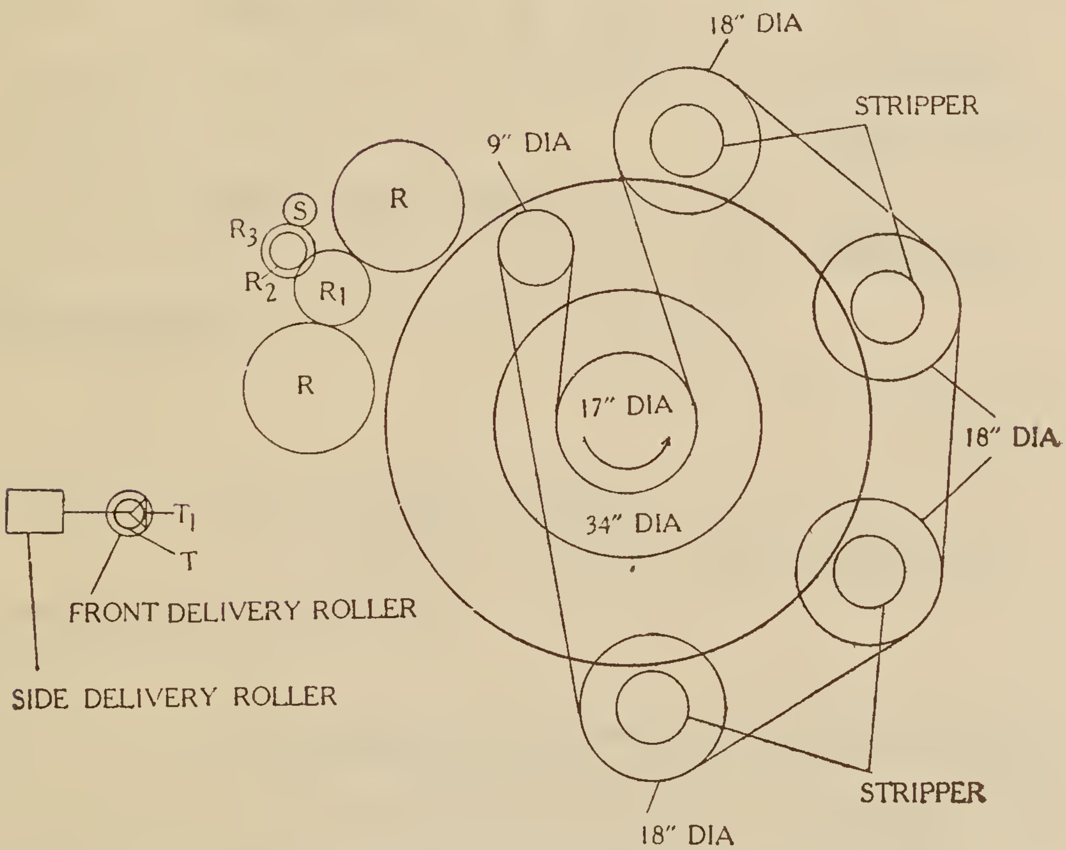
Finisher Card (Mackie) Gearing
Gearing Side

Gearing Side

A	...	Cylinder changes
B	...	Cylinder intermediate
C	...	Feed change D. C.
D	...	Feed changes
E	...	Feed D. C.
F	...	Pinion on feed D. C.
G	...	Feed wheel
G_1	...	Top feed pinion

G_2	...	Bottom feed wheel
H	...	Feed stripper intermediate
H_1	...	Feed stripper wheel
I	...	Sheet roller intermediate
I_1	...	Sheet roller wheel
J	...	Bright roller intermediate
J_1	...	Top Bright roller wheel
J_2	...	Bottom bright roller wheel
K	...	Delivery intermediate
K_1	...	Delivery roller wheel
L	...	Intermediate to worker D. C.
L_1	...	Worker D. C.
L_2	...	Worker changes
L_3	...	Worker stud wheel on socket
L_4	...	Worker stud pinion on socket
L_5	...	Worker wheels
L_6	...	Worker intermediates
M	...	Tin cylinder pinion
M_1	...	1st. tin cylinder wheel
M_2	...	2nd. tin cylinder wheel
N	...	Chain pinion on top feed pinion
N_1	..	Chain wheel D. C.
O	...	Roll feed changes
O_1	...	Chain wheel on bevel D. C.
O_2	...	Bevel D. C.
O_3	...	Bevel on worm shaft
O_4	...	Worms
O_5	...	Inside fluted roller wheel
O_6	...	Outside fluted roller wheel
P	...	Wheel on chain D. C.
P_1	...	Chain D. C. pinion

P_2	...	Chain idler
P_3	...	Chain wheel on back shaft
P_4	...	Chain pinion on back shaft
Pulley Side		
R	...	Doffer wheels
R_1	...	Doffer intermediate
R_2	...	Doffer stud pinion
R_3	...	Doffer stud wheel
S	...	Bright roller pinion
T	...	Delivery roller bevel
T_1	...	Side delivery roller bevel



Finisher Card (Mackie) Gearing—Pulley Side

Delivery speed :

$$\text{cylinder r. p. m.} \times \frac{A}{K_1} \times \frac{T}{T_1} \times \frac{\text{side delivery roller dia.} \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Feed ratio :

$$\frac{1}{\text{bottom feed roller dia.}} \times \frac{G_2}{G_1} \times \frac{G}{F} \times \frac{E}{D} \times \frac{C}{A} \times \frac{\text{cylinder dia.}}{1}$$

Stripper ratio :

$$\frac{1}{\text{stripper dia.}} \times \frac{\text{stripper pulley dia.}}{\text{stripper driving pulley dia.}} \times \frac{\text{cylinder dia.}}{1}$$

Worker ratio :

$$\frac{1}{\text{worker dia.}} \times \frac{L_5}{L_4} \times \frac{L_3}{L_2} \times \frac{L_1}{A} \times \frac{\text{cylinder dia.}}{1}$$

Doffer ratio :

$$\frac{1}{\text{doffer dia.}} \times \frac{R}{R_2} \times \frac{R_3}{S} \times \frac{\text{bright roller wheel}}{A} \times \frac{\text{cylinder dia.}}{1}$$

Draft :

$$\frac{1}{\text{sheet roller dia.}} \times \frac{I_1}{G_1} \times \frac{G}{F} \times \frac{E}{D} \times \frac{C}{K_1} \times \frac{T}{T_1} \times \frac{\text{side delivery roller dia.}}{1}$$

Finisher Card—Production Calculations

(i) Weight per 100 yds. of delivery :

Weight per 100 yds. of breaker delivery ... W_1 lb.
Doublings on finisher card ... N to 1
Draft of finisher card ... D_1
Weight of finisher delivery per 100 yds.

$$= \frac{W_1 \times N}{D_1} = W_2 \text{ lbs.}$$

(ii) Production per day of x hours :

Surface speed of drawing roller ... S_1 f. p. m.

Finisher delivery per hour $= \dfrac{S_1 \times 60}{3}$ yds.

Weight of finisher delivery per hour

$$= \frac{S_1 \times 60 \times W_2}{3 \times 100} \text{ lbs.}$$

Production of finisher card per day of x hours

$$= \frac{S_1 \times 60 \times W_2 \times x}{3 \times 100} \text{ lbs.}$$

Example

Weight of breaker delivery per 100 yds ... 15·03 lbs.
Doubling on finisher card ... 10 to 1
Draft on finisher card ... 15
Surface speed of drawing roller ... 220 f. p. m.
Weight of finisher delivery per 100 yds.

$$= \frac{15{\cdot}03 \times 10}{15} = 10{\cdot}02 \text{ lbs.}$$

Production per day of 10 hours

$$= \frac{220 \times 60 \times 10{\cdot}02 \times 10}{3 \times 100} = 4408{\cdot}80 \text{ lbs.}$$

Problems

(i) In a finisher card a 22 teeth pinion on the drawing roller, drives the doffer wheel of 88 teeth through a double intermediate of 56/28 teeth. The diameters of the doffer and the drawing roller are 20 inches and 4 inches respectively. Find the draft between the drawing roller and the doffer.

$$\frac{4 \times 3{\cdot}14}{22} \times \frac{56}{28} \times \frac{88}{20 \times 3{\cdot}14} = 1{\cdot}60$$

(ii) Find the weight of sliver from a finisher card in lbs. per 100 yds. from the following details :

Breaker card delivery per 100 yds.	...	16 lbs.
Doublings on finisher card	...	10 to 1
Draft on finisher card	...	15

$$\frac{16 \times 10}{15} = 10{\cdot}66 \text{ lbs. per 100 yds.}$$

(iii) The following details are given :

Breaker card clock length	...	12·3 yds.
Breaker card draft	...	10·82
Finisher card doublings	...	10 to 1
Finisher card draft	..	13·97

Find the dollop to produce a finisher card delivery of 12·91 lbs. per 100 yds. allowing 10% for wastage.

$$\frac{\text{Dollop} \times 100}{12{\cdot}3 \times 10{\cdot}82} \times \frac{10}{13{\cdot}97} = 12{\cdot}91$$

$$\text{Dollop} = \frac{12{\cdot}3 \times 10{\cdot}82 \times 13{\cdot}97 \times 12{\cdot}91}{100 \times 10} = 24 \text{ lbs.}$$

Allowing 10% for wastage, dollop $= 24 \times \frac{110}{100} = 26{\cdot}4$ lbs.

(iv) The surface speed of the drawing roller of a finisher card is 210 ft. per min. and the weight of the sliver from the finisher card is 12 lbs. per 100 yds. What would be the production of the finisher card per day of 10 hours at 80% efficiency ?

$$\frac{210 \times 60 \times 10 \times 12 \times 80}{3 \times 100 \times 100} = 4032 \text{ lbs.}$$

(v) The sliver from a breaker card weighs 16 lbs. per 100 yds. 10 such slivers are fed into a finisher card. The draft constant of the finisher card is 342. What would be

the draft pinion on the finisher card to produce a sliver which weighs 11·43 lbs. per 100 yds. ?

$$\frac{16 \times 10}{\text{finisher draft}} = 11{\cdot}43$$

$$\text{Finisher draft} = \frac{16 \times 10}{11{\cdot}43} = 14$$

$$\text{Draft pinion} = \frac{342}{14} = 24{\cdot}43 \text{ say 24 teeth.}$$

CHAPTER VI

PINNING AND SETTING OF CARD ROLLERS

Pinning

The card pins are fixed in staves which are firmly attached to the rollers by stout screws. The method of distribution of the pins over the surfaces of the staves is the pitch of the pins. The pitch of pins of a roller is generally expressed in terms of the distance between two successive pins in two directions—viz. round the circumference of the roller and across the roller. A pitch of $\frac{2}{3}$ in. $\times$ $\frac{3}{4}$ in. means that the distance between two successive rows of pins is $\frac{2}{3}$ inch measured round the roller and the distance between two successive pins in a row is $\frac{3}{4}$ inch. The pitch of pins is usually converted into pins per square inch for comparing the pinning of one roller with that of another roller. The pitch of pins $\frac{A}{B}$ in. $\times \frac{C}{D}$ in. is equivalent to $\frac{B}{A} \times \frac{D}{C}$ pins per square inch.

The size of pins and pitch of pins in a roller mainly depend on the function of the roller, the type of jute to be processed, the quantity of feed and the count of the yarn to be produced. A few suggestions are given below :

Weft Teaser

Name of Roller	Pitch of Pins	Pin Size
Cylinder	$\frac{5}{8}$ in. $\times$ $\frac{9}{16}$ in.	12 B. W. G. $\times 1\frac{1}{8}$ in.
Feed roller	$\frac{9}{16}$,, $\times \frac{1}{2}$,,	11 ,, $\times 1\frac{1}{4}$,,
Strippers	$\frac{5}{8}$,, $\times \frac{1}{2}$,,	12 ,, $\times 1\frac{1}{4}$,,
Workers	$\frac{9}{16}$,, $\times \frac{1}{2}$,,	10 ,, $\times 1\frac{3}{4}$,,
Doffer	$\frac{1}{2}$,, $\times \frac{1}{2}$,,	12 ,, $\times 1\frac{1}{2}$,,

Warp Breaker

Name of Roller	Pitch of Pins	Pin Size
Cylinder	$\frac{9}{16}$ in. $\times \frac{9}{16}$ in.	13 B. W. G. $\times 1\frac{1}{8}$ in.
Feed roller	$\frac{9}{16}$,, $\times \frac{7}{16}$,,	11 ,, $\times 1\frac{1}{4}$,,
Strippers	$\frac{9}{16}$,, $\times \frac{7}{16}$,,	13 ,, $\times 1$,,
Workers	$\frac{7}{16}$,, $\times \frac{7}{16}$,,	13 ,, $\times 1\frac{5}{8}$,,
Doffer	$\frac{7}{16}$,, $\times \frac{7}{16}$,,	14 ,, $\times 1\frac{1}{4}$,,

Weft Breaker

Name of Roller	Pitch of Pins	Pin Size
Cylinder	$\frac{3}{4}$ in. $\times \frac{5}{8}$ in.	12 B. W. G. $\times 1$ in.
Feed roller	$\frac{9}{16}$,, $\times \frac{7}{16}$,,	11 ,, $\times 1\frac{1}{4}$,,
Strippers	$\frac{9}{16}$,, $\times \frac{7}{16}$,,	13 ,, $\times 1$,,
Workers	$\frac{7}{16}$,, $\times \frac{7}{16}$,,	12 ,, $\times 1\frac{5}{8}$,,
Doffer	$\frac{7}{16}$,, $\times \frac{7}{16}$,,	14 ,, $\times 1\frac{1}{4}$,,

Warp Finisher (Half-circular)

Name of Roller	Pitch of Pins	Pin Size
Cylinder	$\frac{7}{16}$ in. $\times \frac{3}{8}$ in.	15 B. W. G. $\times \frac{7}{8}$ in.
Feed roller	$\frac{7}{16}$,, $\times \frac{7}{16}$,,	14 ,, $\times 1\frac{1}{8}$,,
Strippers	$\frac{7}{16}$,, $\times \frac{5}{8}$,,	15 ,, $\times 1$,,
Workers	$\frac{3}{8}$,, $\times \frac{3}{8}$,,	14 ,, $\times 1\frac{1}{2}$,,
Doffer	$\frac{7}{16}$,, $\times \frac{3}{8}$,,	15 ,, $\times 1\frac{1}{8}$,,

Weft Finisher (Half-circular)

Name of Roller	Pitch of Pins	Pin Size
Cylinder	$\frac{7}{16}$ in. $\times \frac{3}{8}$ in.	14 B. W. G. $\times \frac{7}{8}$ in.
Feed roller	$\frac{7}{16}$,, $\times \frac{7}{16}$,,	13 ,, $\times 1\frac{1}{8}$,,
Strippers	$\frac{1}{2}$,, $\times \frac{3}{4}$,,	14 ,, $\times 1$,,
Workers	$\frac{3}{8}$,, $\times \frac{3}{8}$,,	13 ,, $\times 1\frac{1}{2}$,,
Doffer	$\frac{7}{16}$,, $\times \frac{3}{8}$,,	15 ,, $\times 1\frac{1}{8}$,,

Warp Finisher (Full-circular)

Name of Roller	Pitch of Pins	Pin Size
Cylinder	$\frac{3}{8}$ in. × $\frac{3}{8}$ in.	15 B. W. G. × $\frac{7}{8}$ in.
Feed roller	$\frac{3}{8}$,, × $\frac{3}{8}$,,	14 ,, × $\frac{5}{8}$,,
Feed stripper	$\frac{3}{8}$,, × $\frac{3}{8}$,,	15 ,, × 1 ,,
1st. and 2nd. strippers	$\frac{3}{8}$,, × $\frac{3}{8}$,,	15 ,, × 1 ,,
3rd. and 4th. strippers	$\frac{3}{8}$,, × $\frac{5}{16}$,,	15 ,, × 1 ,,
1st. and 2nd. Workers	$\frac{3}{8}$,, × $\frac{5}{16}$,,	14 ,, × $1\frac{1}{2}$,,
3rd. and 4th. Workers	$\frac{3}{8}$,, × $\frac{1}{4}$,,	14 ,, × $1\frac{1}{2}$,,
Doffer	$\frac{5}{16}$,, × $\frac{5}{16}$,,	15 ,, × $1\frac{1}{8}$,,

In the above suggestions "warp" means Hessian warp, Hessian weft and Sacking warp and "weft" means Sacking weft.

Life of Card pins

The life of card pins depends on many factors, such as quality of pins, type of jute, working hours, cleaning of pins and efficiency of the operator. The following table will give an idea of the average effective life of card pins to maintain efficient carding on the basis of 48 working hours per week.

Name of Roller	First Teaser	Second Teaser
Cylinder	2 months	6 months
Feed roller	12 ,,	12 ,,
Strippers	12 ,,	18 ,,
Workers	6 ,,	12 ,,
Doffer	6 ,,	9 ,,

Name of Roller	Warp Breaker	Weft Breaker
Cylinder	6 months	9 months
Feed roller	12 ,,	24 ,,

Name of Roller	Warp Breaker	Weft Breaker
Strippers	18 months	18 months
Workers	12 ,,	12 ,,
Doffer	12 ,,	12 ,,

Name of Roller	Warp Finisher	Weft Finisher
Cylinder	18 months	18 months
Feed roller	24 ,,	24 ,,
Strippers	60 ,,	60 ,,
Workers	36 ,,	36 ,,
Doffer	24 ,,	24 ,,

Setting of Rollers

For efficient carding the rollers should be properly placed in relation to each other. This setting is to be modified according to the quality of jute, the quantity of feed and the count of the yarn to be produced. Finer yarns need closer setting and heavier yarns require wider setting.

Roller Setting	Teaser	Warp Breaker	Warp Finisher (Half-circular)
Feed Roller to shell	$\frac{1}{8}$ in.	clear	clear
Feed roller to cylinder	12 B. W. G.	12 B. W. G.	14 B. W. G.
Shell to cylinder	$\frac{3}{8}$ in.	$\frac{1}{4}$ in.	$\frac{3}{16}$ in.
1st. stripper to cylinder	14 B. W. G.	16 B. W. G.	16 B. W. G.
1st. worker to cylinder	12 ,,	14 ,,	15 ,,
1st stripper to 1st. worker	14 ,,	16 ,,	16 ,,

Roller Setting	Teaser	Warp Breaker	Warp Finisher (Half-circular)
2nd. stripper to cylinder	14 B. W. G.	16 B. W. G.	17 B. W. G.
2nd. worker to cylinder	12 ,,	14 ,,	17 ,,
2nd. stripper to 2nd. worker	14 ,,	16 ,,	17 ,,
3rd. stripper to cylinder	—	—	17 ,,
3rd. worker to cylinder	—	—	17 ,,
3rd. stripper to 3rd. worker	—	—	17 ,,
Doffer to cylinder	14 ,,	16 ,,	17 ,,
Drawing roller to doffer	$\frac{1}{4}$ in.	$\frac{3}{16}$ in.	$\frac{3}{16}$ in.
Pressing roller to doffer	$1\frac{1}{2}$,,	$1\frac{1}{2}$,,	$1\frac{1}{2}$,,

Roller Setting	Warp Finisher (Double-Doffer)
Plain roller to feed roller	15 B. W. G.
Plain roller to cylinder	15 ,,
Feed roller to cylinder	15 ,,
Feed stripper to feed roller	17 ,,
Feed stripper to cylinder	16 ,,
1st. stripper to cylinder	16 ,,
2nd. stripper to cylinder	16 ,,
3rd. stripper to cylinder	17 ,,
4th. stripper to cylinder	17 ,,

Roller Setting	Warp Finisher (Double-Doffer)	
1st. stripper to 1st. worker	16	B. W. G.
2nd. stripper to 2nd. worker	16	,,
3rd. stripper to 3rd. worker	17	,,
4th. stripper to 4th. worker	17	,,
1st. worker to cylinder	13	,,
2nd. worker to cylinder	13	,,
3rd. worker to cylinder	14	,,
4th. worker to cylinder	14	,,
Top doffer to cylinder	17	,,
Bottom doffer to cylinder	18	,,
Top doffer to drawing roller	$1\frac{3}{16}$	in.
Top doffer to pressing roller	$\frac{1}{8}$	,,
Bottom doffer to drawing roller	$1\frac{5}{16}$	,,
Bottom doffer to pressing roller	$\frac{3}{4}$	,,

Problems

(i) The pitch of one roller is $\frac{3}{4}$ in. $\times \frac{5}{8}$ in. and that of the other roller is $\frac{5}{8}$ in. $\times \frac{5}{8}$ in. Compare the number of pins per square inch of the rollers.

Pins per square inch of the first roller $= \frac{4}{3} \times \frac{8}{5} = 2{\cdot}13$

Pins per square inch of the second roller $= \frac{8}{5} \times \frac{8}{5} = 2{\cdot}56.$

(ii) Find the number of pins in a roller with pitch of pins $\frac{3}{4}$ in. $\times \frac{3}{4}$ in., the length and diameter of the roller being 70 inches and 48 inches respectively.

Area of the surface of the roller

$= 48 \times 3{\cdot}14 \times 70 = 10550{\cdot}40$ sq. in.

Number of pins in the roller

$$= 10550{\cdot}40 \times \frac{4}{3} \times \frac{4}{3} = 18756.$$

CHAPTER VII

THE DRAWING FRAMES

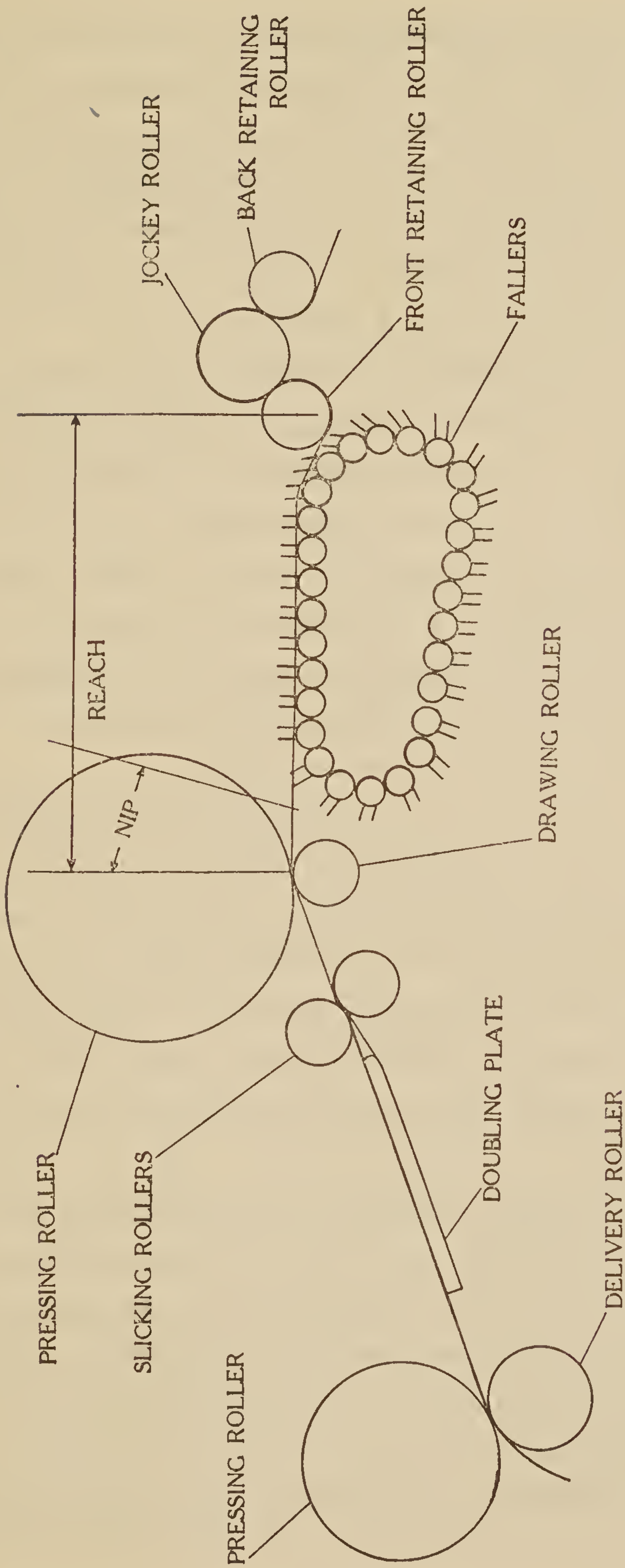
Drawing and Doubling

The sliver delivered by the finisher card is not so even and the fibres are not properly straightened. So the sliver is subjected to the process of "drawing and doubling".

Doubling is the combination of several slivers to make the resultant sliver more uniform. In the doubling process the thick portion of one sliver may combine with the thin portion of another sliver and vice versa, thus making the resultant sliver more uniform than the singles. On the other hand, if the thick portion of one sliver coincides with the thick portion of another sliver or the thin portion of one coincides with the thin portion of the other, the resultant sliver will not be worse than the components. As the process of doubling will make the resultant sliver very thick, it is counter-balanced by the drafting of the single slivers. The machine in which the sliver is subjected to the process of drawing and doubling, is known as the Drawing Frame. Usually two drawing frames and sometimes three drawing frames are successively employed to get the required levelness in the sliver.

The Drawing Frame

The main parts of a drawing frame are retaining rollers, fallers, drawing rollers, doubling plate and delivery rollers. The sliver passes under the back retaining roller, over the jockey roller and then under the front retaining roller. As the sliver leaves the retaining roller, it is picked up and



Drawing Frame

carried forward by pinned gills until it is taken up by the drawing rollers. Then it passes through the slicking rollers. After leaving the slicking rollers, the sliver passes through the diagonal slots of the doubling plate where the required number of slivers are doubled into one and finally passes out through the delivery rollers to be collected in a can or made into a roll in a roll-former.

Reach is the distance between the front retaining roller and the point of contact of the drawing roller and the pressing roller. The reach must be longer than the longest fibre in the sliver. If the reach is too short, the longer fibres will be gripped by both ends at the same time, stretched and broken. If the reach is too long, the loose fibres will be uncontrolled causing a very irregular sliver. The reach will be correct if the fibres are held by only one end at a time, yet not left uncontrolled.

Nip is the distance between the point of contact of the drawing roller and the pressing roller and the point at which the gill pins leave the sliver as the gill is descending. The shorter the nip, the more efficient the drawing frame. If the nip is not reasonably short, the gills drop before approaching close to the drawing roller, thus drawing the sliver irregularly causing thicks and thins in the resultant sliver.

The lead of faller over the retaining roller is the excess surface speed of faller over that of the retaining roller. This is very small and is expressed as a percentage figure calculated on the surface speed of the retaining roller. This lead of faller keeps the sliver in tension which is essential for proper pinning.

The lead of delivery roller over drawing roller keeps

the sliver in tension on the doubling plate and thus aids the movement of the sliver on the doubling plate.

Types of Drawing Frames

In the jute industry, the following types of drawing frames are used :

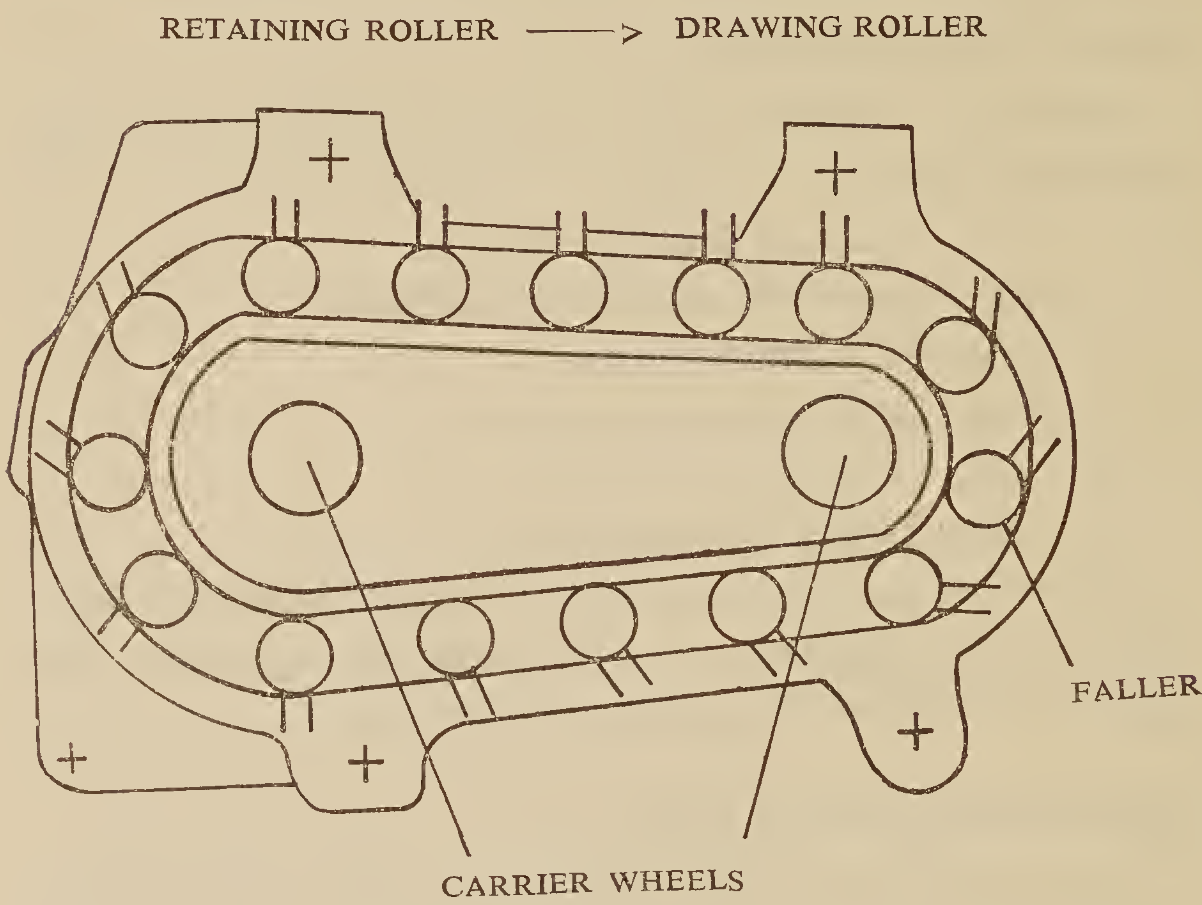
(i) Push-bar drawing frame
(ii) Open-link chain drawing frame
(iii) Ring drawing frame
(iv) Spiral drawing frame
(v) Circular drawing frame
(vi) Rotary drawing frame.

These are more or less similar in main essentials. They differ in gill mechanism. The push-bar type and the spiral type drawing frames are in wide use.

The Push-bar Drawing Frame

In a Push-bar drawing frame, two carrier wheels drive the fallers on a slide between the retaining roller and the drawing roller. When the fallers are out of contact with the carrier wheels, these are pushed forward both at the top and at the bottom by the fallers which come behind them. A short crank carrying a pin is attached to one end of each faller, at right angles to the pins. The fallers and the crank pins move on different slides. The relative positions of the two slides keep the cranks in a horizontal position while the fallers move along the top and the gill pins upright. The faller and the crank drop down at the same time, the crank being in a horizontal position and the pins upright until they are clear of the sliver and past the drawing roller. As the fallers move along the bottom,

the slide for the crank pins turns the cranks slowly round. As the faller rises, its crank pin is forced outwards. When



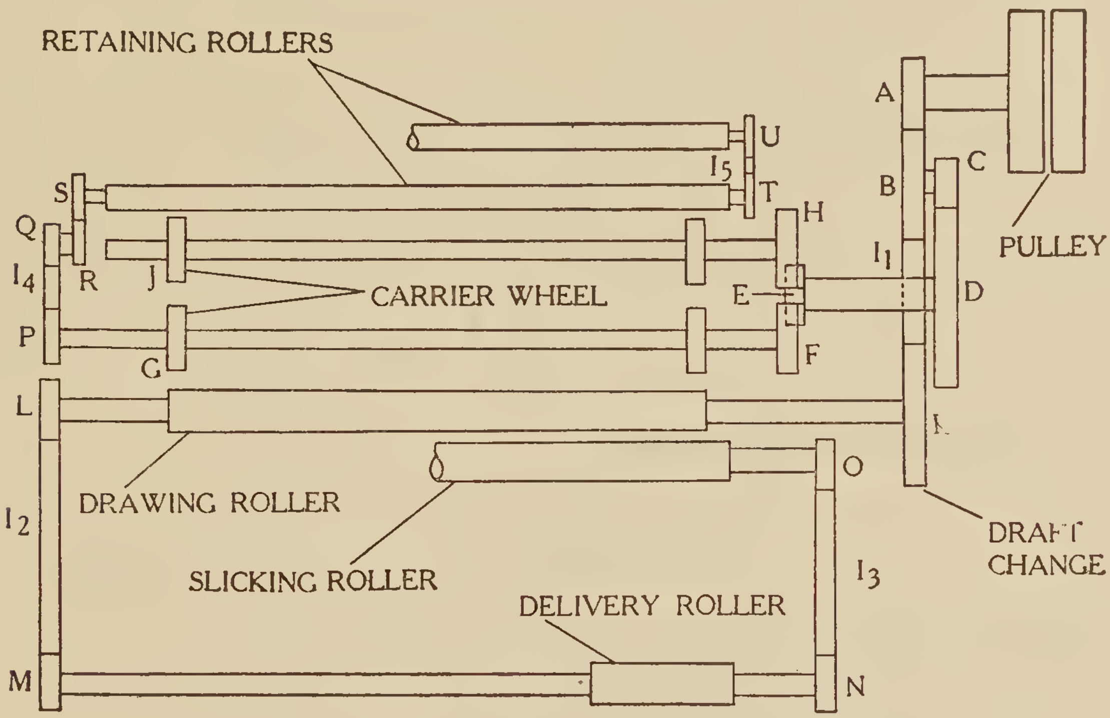
Push-Bar Drawing Frame—Faller Drive

pins enter the sliver, the cranks are again horizontal and the gill pins upright.

Push-bar Drawing Frame Gearing—Speed Calculations

The pulleys are driven by the drum on the driving shaft through belting. The pulley speed pinion A on the pulley shaft, drives the drawing roller wheel K through two single intermediates B any I_1. The pinion L on the other end of the drawing roller shaft drives the delivery roller wheel M through a single intermediate I_2. The pinion N on the other end of the delivery roller shaft drives the slicking roller wheel O through a single intermediate I_3.

The pulley speed pinion A, again, drives the front carrier shaft wheel F and back carrier shaft wheel H through two double intermediates B/C and D/E. The front carrier wheel G on the front carrier shaft and the back carrier



Push-Bar Drawing Frame Gearing

wheel J on the back carrier shaft drive the fallers. The pinion P on the other end of the front carrier shaft drive the front retaining roller wheel S through a single intermediate I_4 and a double intermediate Q/R. The pinion T on the other end of the front retaining roller shaft drives the back retaining roller wheel U through a single intermediate I_5.

Driving shaft speed	...	...	V r. p. m.
Diameter of drum	...	...	b inches
Diameter of pulley	...	...	c ,,
Diameter of drawing roller		...	d ,,
Diameter of delivery roller		...	e ,,

Diameter of slicking roller ...	f	inches
Diameter of retaining roller ...	g	,,
Pitch of a tooth of front carrier wheel	h	,,

Pulley speed :

$$V \times \frac{b}{c} \text{ r. p. m.}$$

Drawing roller speed :

$$V \times \frac{b}{c} \times \frac{A}{K} \text{ r. p. m.}$$

$$V \times \frac{b}{c} \times \frac{A}{K} \times \frac{d \times 3{\cdot}14}{12} = k \text{ f. p. m.}$$

Delivery roller speed :

$$V \times \frac{b}{c} \times \frac{A}{K} \times \frac{L}{M} \text{ r. p. m.}$$

$$V \times \frac{b}{c} \times \frac{A}{K} \times \frac{L}{M} \times \frac{e \times 3{\cdot}14}{12} = m \text{ f. p. m.}$$

Slicking roller speed :

$$V \times \frac{b}{c} \times \frac{A}{K} \times \frac{L}{M} \times \frac{N}{O} \text{ r. p. m.}$$

$$V \times \frac{b}{c} \times \frac{A}{K} \times \frac{L}{M} \times \frac{N}{O} \times \frac{f 3{\cdot}14}{12} \text{ f. p. m.}$$

Faller speed :

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{G}{1} \text{ drops per min.}$$

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{G}{1} \times \frac{h}{1} = q \text{ inches per min.}$$

Retaining roller speed :

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{P}{Q} \times \frac{R}{S} \text{ r. p. m.}$$

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{P}{Q} \times \frac{R}{S} \times \frac{g \times 3{\cdot}14}{12} = s \text{ f.p.m.}$$

Draft between drawing roller and retaining roller

$$=\frac{k}{s}=Y$$

Draft Constant

$$=\frac{d\times 3{\cdot}14}{1}\times\frac{B}{C}\times\frac{D}{E}\times\frac{F}{P}\times\frac{Q}{R}\times\frac{S}{g\times 3{\cdot}14}=X$$

Draft $=\dfrac{\text{Draft constant}}{\text{Change pinion}}=\dfrac{X}{K}=Y$

Speed ratio between delivery roller and drawing roller:

$$\frac{m}{k}=Z$$

$$\frac{e\times 3{\cdot}14}{M}\times\frac{L}{d\times 3{\cdot}14}=Z$$

Lead of faller over retaining roller:

$$\frac{(\text{S.S. of faller}-\text{S.S. of retaining roller})\times 100}{\text{S. S. of retaining roller}}\%$$

$$\frac{(q-s\times 12)\times 100}{s\times 12}\%$$

Example

Driving shaft speed	200 r. p. m.
Diameter of drum	20 inches
Diameter of pulley	16 ,,
Pulley speed pinion (to drawing roller)	33 teeth
Drawing roller wheel (change pinion)	60 ,,
Diameter of drawing roller ...	2·5 inches
Pinion on off end of drawing roller (to delivery roller)	28 teeth
Delivery roller wheel	37 ,,
Diameter of delivery roller ...	3·5 inches

Pinion on off end of delivery roller (to slicking roller)	37	teeth
Slicking roller wheel	27	,,
Diameter of slicking roller ...	2·375	inches
Pulley speed pinion (to fallers) ...	33	teeth
Double intermediate	52/20	,,
Double intermediate	84/27	,,
Front carrier shaft wheel ...	42	,,
Front carrier wheel	14	,,
Pitch of a tooth of front carrier wheel	$\frac{7}{8}$	inch
Pinion on off end of front carrier shaft (to retaining roller)	42	teeth
Double intermediate	22/39	,,
Retaining roller wheel	42	,,
Diameter of retaining roller ...	2	inches

Pulley speed :

$$200 \times \frac{20}{16} = 250 \text{ r. p. m.}$$

Drawing roller speed :

$$200 \times \frac{20}{16} \times \frac{33}{60} = 137{\cdot}5 \text{ r. p. m.}$$

$$137{\cdot}5 \times \frac{2{\cdot}5 \times 3{\cdot}14}{12} = 89{\cdot}95 \text{ f. p. m.}$$

Delivery roller speed :

$$200 \times \frac{20}{16} \times \frac{33}{60} \times \frac{28}{37} = 104{\cdot}05 \text{ r. p. m.}$$

$$104{\cdot}05 \times \frac{3{\cdot}5 \times 3{\cdot}14}{12} = 95{\cdot}29 \text{ f. p. m.}$$

Slicking roller speed :

$$200 \times \frac{20}{16} \times \frac{33}{60} \times \frac{28}{37} \times \frac{37}{27} = 142{\cdot}59 \text{ r. p. m.}$$

$$142{\cdot}59 \times \frac{2{\cdot}375 \times 3{\cdot}14}{12} = 88{\cdot}61 \text{ f. p. m.}$$

Faller speed :

$$200 \times \frac{20}{16} \times \frac{33}{52} \times \frac{20}{84} \times \frac{27}{42} \times \frac{14}{1} = 339{\cdot}97 \text{ drops per min.}$$

$$339{\cdot}97 \times \frac{7}{8} = 297{\cdot}47 \text{ inches per min.}$$

Retaining roller speed :

$$200 \times \frac{20}{16} \times \frac{33}{52} \times \frac{20}{84} \times \frac{27}{42} \times \frac{42}{22} \times \frac{39}{42} = 43{\cdot}05 \text{ r. p. m.}$$

$$43{\cdot}05 \times \frac{2 \times 3{\cdot}14}{12} = 22{\cdot}52 \text{ f. p. m.}$$

Draft between drawing roller and retaining roller

$$= \frac{89{\cdot}95}{22{\cdot}52} = 3{\cdot}99$$

$$\text{Draft constant} = \frac{2{\cdot}5 \times 3{\cdot}14}{1} \times \frac{52}{20} \times \frac{84}{27} \times \frac{42}{42} \times \frac{22}{39} \times \frac{42}{3{\cdot}5 \times 3{\cdot}14} = 239{\cdot}5$$

$$\text{Draft} = \frac{239{\cdot}5}{60} = 3{\cdot}99$$

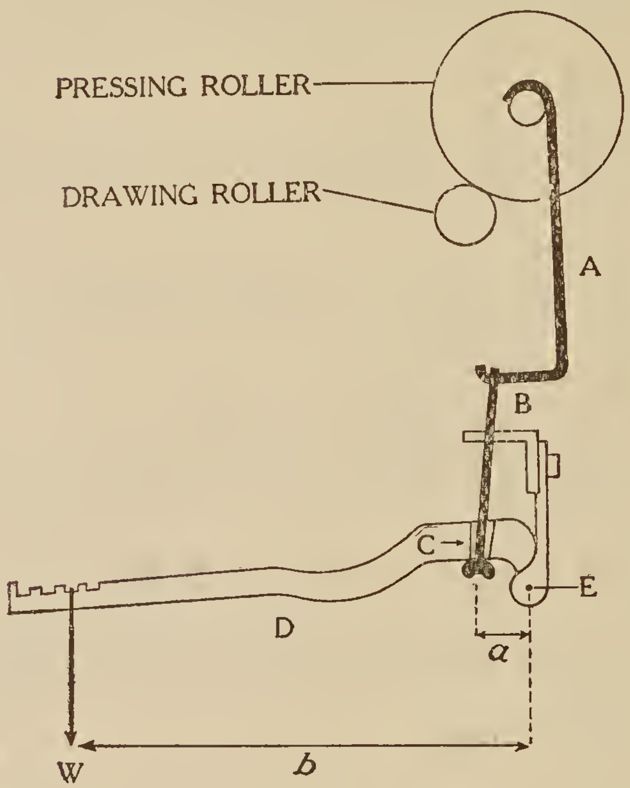
Lead of faller over retaining roller

$$= \frac{(297{\cdot}47 - 22{\cdot}52 \times 12) \times 100}{22{\cdot}52 \times 12} = 10{\cdot}07\%$$

Pressure between Drawing Roller and Pressing roller

A strap A bears on the axle of the pressing roller and is connected to the point C of the lever D through the

wire B and an adjusting thumb screw. The lever D is hinged at E. A weight W is attached to the lever to give pressure.



Push-Bar Drawing Frame
Drawing and Pressing Rollers

$$b \times W = P \times a$$

where, b = distance between E and the centre of W
a = distance between C and E
P = pressure at C

Hence $P = \dfrac{b \times W}{a} = d$ lbs.

Since similar arrangement is at the other end of the pair of pressing rollers, the total pressure on them is equal to $2 \times d$ lbs. As each roller of the pair is e inches broad, pressure per inch of face is equal to $\dfrac{2 \times d}{2 \times e}$ lbs.

Example

Weight on the lever	24 lbs.
Distance between E and the centre of the weight ...	18 inches
Distance between C and E	1·75 "
Roller face	7 "

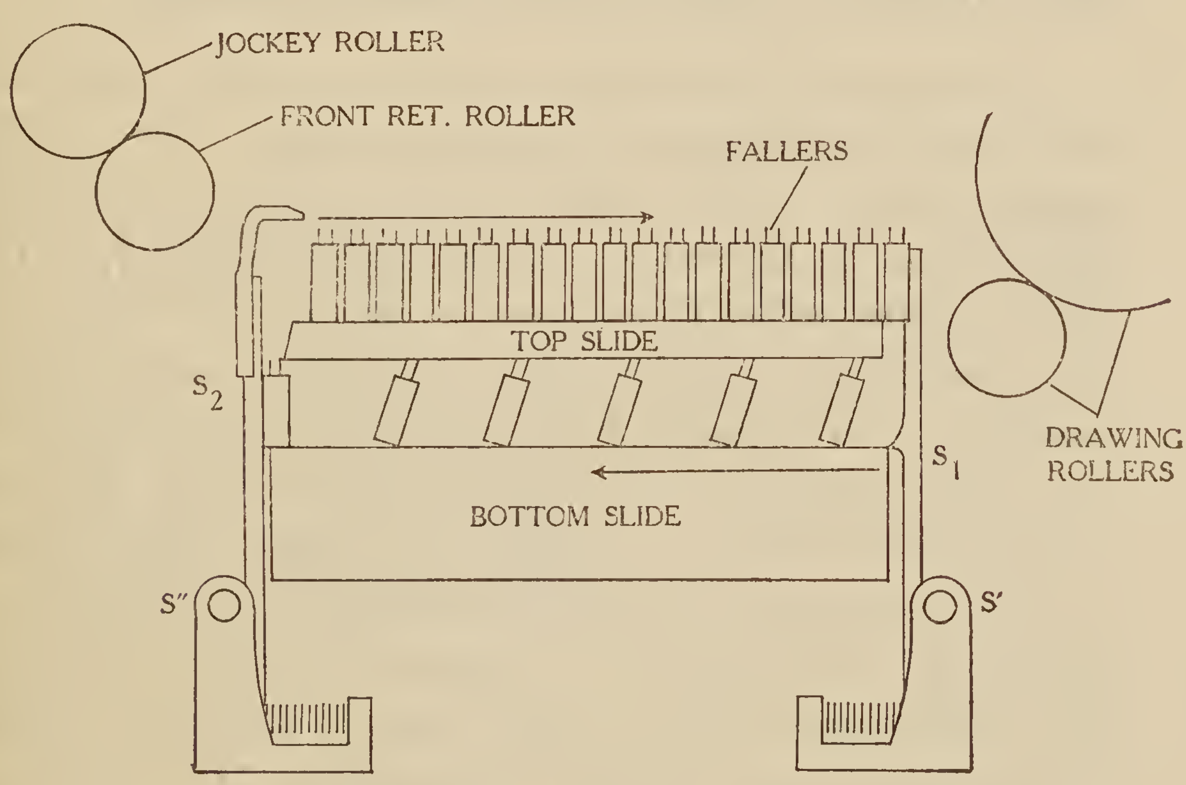
$$\text{Pressure at C} = \frac{24 \times 18}{1{\cdot}75} = 246{\cdot}85 \text{ lbs.}$$

Total pressure on the pair of pressing rollers
$= 246{\cdot}85 \times 2 = 493{\cdot}70$ lbs.

$$\text{Pressure per inch of face} = \frac{493{\cdot}70}{2 \times 7} = 35{\cdot}26 \text{ lbs.}$$

The Spiral Drawing Frame

In the spiral drawing frame the fallers move in a rectangular path and thus the gill pins enter and leave the sliver in a way to ensure good pinning.



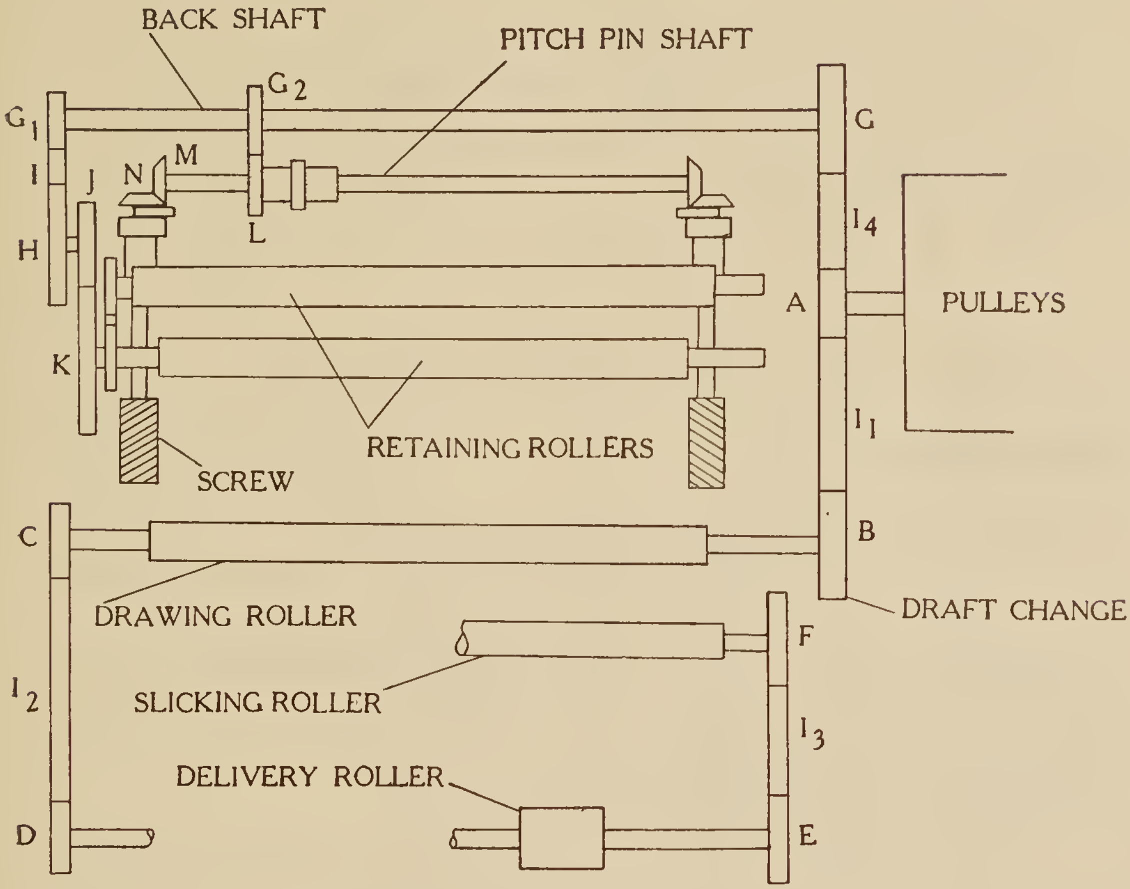
Spiral Drawing Frame—Faller Drive

There are two slides, one top and the other bottom. The fallers are driven along these slides. The top screw drives the fallers along the top slide. As each faller reaches the end of the top slide, the check spring S_1 which is hinged at S', is pushed away from the slide to allow the faller to drop on the bottom slide. This movement of faller to the bottom slide is assisted by a cam on the top screw and the faller drops correctly on the thread of the bottom screw. The bottom screw is coarser in pitch than the top screw. The bottom screw drives the fallers along the bottom slide. As each faller reaches the end of the bottom slide the check spring S_2 which is hinged at S'' is pushed back by the faller which is then raised to the top slide by a cam on the bottom screw.

Spiral Drawing Frame Gearing—Speed Calculations

The fast and loose pulleys receive the motion from the drum on the driving shaft through belting. The pulley speed pinion A on the pulley shaft, drives the drawing roller wheel B through a single intermediate I_1. The delivery roller wheel D is driven by the pinion C on the other end of the drawing roller through a single intermediate I_2. The pinion E on the other end of the delivery roller shaft drives the slicking roller wheel F through a single intermediate I_3. Again, the pulley speed pinion A drives the back shaft wheel G through one single intermediate I_4. The pinion G_1 on the other end of the back shaft, drives the retaining roller wheel K through a single intermediate I and a double intermediate H/J. Another pinion G_2 on the back shaft drives the pitch pin shaft

wheel L. The bevel pinions M on the pitch pin shaft, drives the bottom screw bevel pinions N.



Spiral Drawing Frame Gearing

Driving shaft speed	...	V r. p. m.
Diameter of drum	...	b inches
Diameter of pulley	...	c ,,
Diameter of drawing roller	...	d ,,
Diameter of delivery roller	...	e ,,
Diameter of slicking roller	...	f ,,
Diameter of retaining roller	...	g ,,
Pitch of screw	...	h ,,

Pulley speed :

$$V \times \frac{b}{c} \text{ r. p. m.}$$

Drawing roller speed :

$$V \times \frac{b}{c} \times \frac{A}{B} \text{ r. p. m.}$$

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{d \times 3{\cdot}14}{12} = k \text{ f. p. m.}$$

Delivery roller speed :

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \text{ r. p. m.}$$

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{e \times 3{\cdot}14}{12} = m \text{ f. p. m.}$$

Slicking roller speed :

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \text{ r. p. m.}$$

$$V \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{f \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Retaining roller speed :

$$V \times \frac{b}{c} \times \frac{A}{G} \times \frac{G_1}{H} \times \frac{J}{K} \text{ r. p. m.}$$

$$V \times \frac{b}{c} \times \frac{A}{G} \times \frac{G_1}{H} \times \frac{J}{K} \times \frac{g \times 3{\cdot}14}{12} = s \text{ f. p. m.}$$

Faller speed :

$$V \times \frac{b}{c} \times \frac{A}{G} \times \frac{G_2}{L} \times \frac{M}{N} \text{ drops per min.}$$

$$V \times \frac{b}{c} \times \frac{A}{G} \times \frac{G_2}{L} \times \frac{M}{N} \times \frac{h}{1} = q \text{ inches per min.}$$

Draft between drawing roller and retaining roller $= \frac{k}{s} = Y$

Draft Constant $= \frac{d \times 3{\cdot}14}{1} \times \frac{G}{G_1} \times \frac{H}{J} \times \frac{K}{g \times 3{\cdot}14} = X$

Draft $= \frac{\text{Draft constant}}{\text{Change pinion}} = \frac{X}{B} = Y$

Speed ratio between delivery roller and drawing roller :

$$\frac{m}{k} = Z$$

$$\frac{e \times 3{\cdot}14}{D} \times \frac{C}{d \times 3{\cdot}14} = Z$$

Lead of faller over retaining roller :

$$\frac{(q - s \times 12) \times 100}{s \times 12}\%$$

Example

Driving shaft speed	...	200 r. p. m.
Diameter of drum	...	16 inches
Diameter of pulley	...	16 ,,
Pulley speed pinion (to drawing roller)		26 teeth
Drawing roller wheel (change pinion)		46 ,,
Diameter of drawing roller	...	2·5 inches
Pinion on off end of drawing roller (to delivery roller)	...	41 teeth
Delivery roller wheel		56 ,,
Diameter of delivery roller	...	3·5 inches
Pinion on off end of delivery roller (to slicking roller)	...	56 teeth
Slicking roller wheel	...	39 ,,
Diameter of slicking roller	...	2·375 inches
Pulley speed pinion (to retaining roller)		26 teeth
Back shaft wheel	...	35 ,,
Pinion on off end of back shaft	...	25 ,,
Double intermediate	...	68/25 ,,
Retaining roller wheel	...	69 ,,
Diameter of retaining roller	...	2 inches
Pinion on back shaft (to fallers)	...	19 teeth
Pitch pin shaft wheel	...	19 ,,

Pitch pin shaft bevel pinion	...	21	teeth
Bottom screw bevel pinion	...	14	,,
Pitch of screw	...	$\frac{4}{7}$	inch

Pulley speed :

$$200 \times \frac{16}{16} = 200 \text{ r. p. m.}$$

Drawing roller speed :

$$200 \times \frac{16}{16} \times \frac{26}{46} = 113{\cdot}04 \text{ r. p. m.}$$

$$113{\cdot}04 \times \frac{2{\cdot}5 \times 3{\cdot}14}{12} = 73{\cdot}95 \text{ f. p. m.}$$

Delivery roller speed :

$$200 \times \frac{16}{16} \times \frac{26}{46} \times \frac{41}{56} = 82{\cdot}76 \text{ r. p. m.}$$

$$82{\cdot}76 \times \frac{3{\cdot}5 \times 3{\cdot}14}{12} = 75{\cdot}79 \text{ f. p. m.}$$

Slicking roller speed :

$$200 \times \frac{16}{16} \times \frac{26}{46} \times \frac{41}{56} \times \frac{56}{39} = 118{\cdot}58 \text{ r. p. m.}$$

$$118{\cdot}58 \times \frac{2{\cdot}375 \times 3{\cdot}14}{12} = 73{\cdot}69 \text{ f. p. m.}$$

Retaining roller speed :

$$200 \times \frac{16}{16} \times \frac{26}{35} \times \frac{25}{68} \times \frac{25}{69} = 19{\cdot}79 \text{ r. p. m.}$$

$$19{\cdot}79 \times \frac{2 \times 3{\cdot}14}{12} = 10{\cdot}35 \text{ f. p. m.}$$

Faller speed :

$$200 \times \frac{16}{16} \times \frac{26}{35} \times \frac{19}{19} \times \frac{21}{14} = 222{\cdot}86 \text{ drops per min.}$$

$$222{\cdot}86 \times \frac{4}{7} = 127{\cdot}34 \text{ inches per min.}$$

Draft between drawing roller and retaining roller

$$= \frac{73{\cdot}95}{10{\cdot}35} = 7{\cdot}14$$

$$\text{Draft Constant} = \frac{2{\cdot}5 \times 3{\cdot}14}{1} \times \frac{35}{25} \times \frac{68}{25} \times \frac{69}{2 \times 3{\cdot}14} = 328{\cdot}44$$

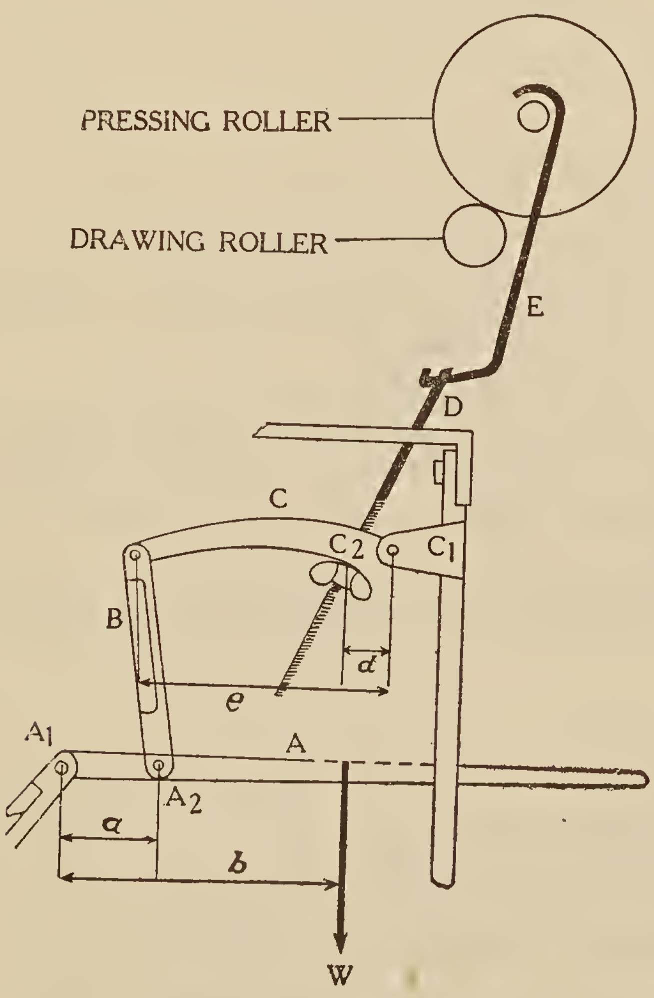
$$\text{Draft} = \frac{328{\cdot}44}{46} = 7{\cdot}14$$

Lead of faller over retaining roller

$$= \frac{(127{\cdot}34 - 10{\cdot}35 \times 12) \times 100}{10{\cdot}35 \times 12} = 2{\cdot}53\%$$

Pressure between Drawing roller and Pressing roller

A strap E bears on the axle of the pressing roller. An



Spiral Drawing Frame
Drawing and Pressing Rollers

eye bolt D with an adjusting thumbscrew connects the lever C to the strap E at a point C_2 on the lever C. The lever C is hinged at C_1. The end of this lever is connected to a point A_2 on another lever A by a strap B. The lever A is hinged at A_1. A weight W is hung on the lever A.

$$F_1 \times a = W \times b$$

$$F_1 = \frac{W \times b}{a}$$

where, F_1 = pull at A_2

a = distance between A_1 and A_2

b = distance between A_1 and centre of W.

$$F_2 \times d = F_1 \times e$$

$$F_2 = \frac{F_1 \times e}{d}$$

where, F_2 = pull at C_2

d = distance between C_1 and C_2

e = distance between C_1 and the point at which B and C meet.

This pull is communicated to the axle of the pressing roller. There is only one set of levers and weight to each pair of pressing rollers. As each roller of the pair is f inches broad, pressure per inch of face is equal to $\frac{F_2}{2 \times f}$ lbs.

Example

Weight on the lever A	...	15 lbs.
Distance between A_1 and A_2	...	2·5 inches.
Distance between A_1 and centre of the weight	...	12·5 ,,
Distance between C_1 and C_2	...	2 ,,

Distance between C_1 and the point of contact of B and C ... 10 inches

Roller face ... 4 ,,

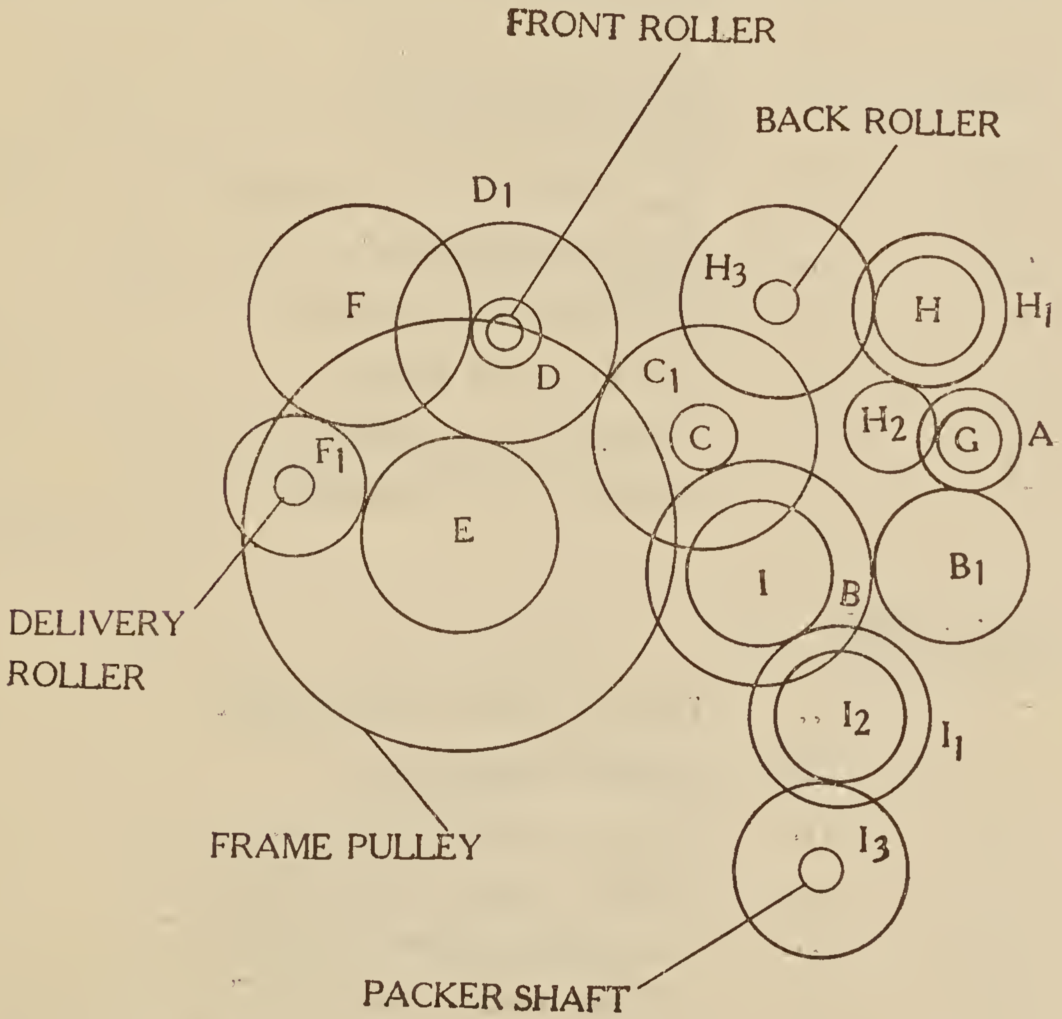
Pull at $A_2 = \frac{15 \times 12{\cdot}5}{2{\cdot}5} = 75$ lbs.

Pull at $C_2 = \frac{75 \times 10}{2} = 375$ lbs.

Pressure per inch of roller face

$$= \frac{375}{2 \times 4} = 46{\cdot}88 \text{ lbs.}$$

Finisher Drawing Frame (Mackie) Gearing—Calculations



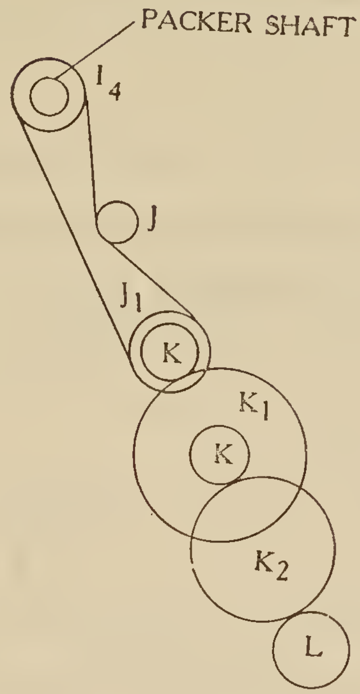
Finisher Drawing Frame (Mackie) Gearing
Pulley side

Pulley Side

A	...	Draft changes
B	...	Draft intermediate no. 1
B_1	...	Draft intermediate no. 2
C	...	Stud pinion
C_1	...	Stud wheel
D	...	Front roller pinion
D_1	...	Front roller wheel
E	...	Speed pinion
F	...	Delivery roller intermediate
F_1	...	Delivery roller wheel
G	...	Back shaft pinion
H	...	Back stud pinion
H_1	...	Back stud wheel
H_2	...	Back shaft intermediate
H_3	...	Back roller wheel
I	...	Packer driving pinion
I_1	...	Packer stud wheel
I_2	...	Packer stud pinion
I_3	...	Packer shaft wheel

Gearing Side

I_4	...	Packer shaft chain wheel
J	...	Chain wheel idler
J_1	...	Chain wheel on D. C.
K	...	Coiler spur wheel D. C.
K_1	...	2nd. coiler spur wheel D. C.
K	...	Coiler spur wheel D. C.
K_2	...	Coiler shaft intermediate
L	...	Coiler shaft wheel



Finisher Drawing Frame (Mackie) Gearing—Gearing Side

Draft Constant :

$$\frac{D_1}{C_1} \times \frac{C}{1} \times \frac{G}{H_1} \times \frac{H}{H_3} \times \frac{\text{back roller dia.}}{\text{front roller dia.}}$$

Draft :

$$\frac{\text{Draft change pinion}}{\text{Draft constant}}$$

% Faller lead :

$$\frac{H_3}{H} \times \frac{H_1}{G} \times \frac{\text{back shaft bevel}}{\text{screw bevel}} \times \frac{\text{pitch of top screw}}{1}$$

$$\times \frac{x}{1} \times \frac{1}{\text{back roller dia.} \times 3{\cdot}14} \times \frac{100}{1}$$

$x = 1$ in case of single cams

$x = 2$ in case of double cams

$x = 3$ in case of triple cams

% Delivery roller lead

$$\left(\frac{D}{F_1} \times \frac{\text{delivery roller dia.} \times 3{\cdot}14}{\text{front roller dia.} \times 3{\cdot}14} \times \frac{100}{1}\right) - 100$$

Drawing Frame-Production Calculations

(i) Weight per 100 yards of delivery of 1st. drawing frame :

Weight per 100 yards of finisher delivery... W_2 lbs.
Doublings on 1st. drawing frame ... N_1 to 1
Draft on 1st. drawing frame ... D_2
Weight of 1st. drawing delivery per 100 yards

$$= \frac{W_2 \times N_1}{D_2} = W_3 \text{ lbs.}$$

(ii) Production of 1st. drawing frame per day of x hours :

Surface speed of drawing roller ... S_2 f. p. m.
Number of deliveries per frame ... T

$$\text{1st. drawing delivery per hour} = \frac{S_2 \times 60 \times T}{3} \text{ yds.}$$

Weight of 1st. drawing delivery per hour

$$= \frac{S_2 \times 60 \times T \times W_3}{3 \times 100} \text{ lbs.}$$

Production of 1st. drawing frame per day

$$\text{of } x \text{ hours} = \frac{S_2 \times 60 \times T \times W_3 \times x}{3 \times 100} \text{ lbs.}$$

(iii) Weight per 100 yards of delivery of 2nd. drawing frame :

Weight per 100 yards of 1st. drawing delivery ... W_3 lbs.
Doublings on 2nd. drawing frame ... N_2 to 1
Draft on 2nd. drawing frame ... D_3
Weight of 2nd. drawing delivery

$$\text{per 100 yards} = \frac{W_3 \times N_2}{D_3} = W_4 \text{ lbs.}$$

(iv) Production of 2nd. drawing frame per day of x hours :

Surface speed of drawing roller ... S_3 f. p. m.
Number of deliveries per frame ... T_1

2nd. drawing delivery per hour $= \frac{S_3 \times 60 \times T_1}{3}$ yds.

Weight of 2nd. drawing delivery

per hour $= \frac{S_3 \times 60 \times T_1 \times W_4}{3 \times 100}$ lbs.

Production of 2nd drawing frame

per day of x hours $= \frac{S_3 \times 60 \times T_1 \times W_4 \times x}{3 \times 100}$ lbs.

(v) Weight per 100 yards of delivery of 3rd. drawing frame:

Weight per 100 yards of 2nd. drawing delivery ... W_4 lbs.
Doublings on 3rd. drawing frame ... N_3 to 1
Draft on 3rd. drawing frame ... D_4
Weight of 3rd. drawing delivery

per 100 yards $= \frac{W_4 \times N_3}{D_4} = W_5$ lbs.

(vi) Production of 3rd. drawing frame per day of x hours:

Surface speed of drawing roller ... S_4 f. p. m.
Number of deliveries per frame ... T_2

3rd. drawing delivery per hour $= \frac{S_4 \times 60 \times T_2}{3}$ yds.

Weight of 3rd. drawing delivery

per hour $= \frac{S_4 \times 60 \times T_2 \times W_5}{3 \times 100}$ lbs.

Production of 3rd. drawing frame

per day of x hours $= \frac{S_4 \times 60 \times T_2 \times W_5 \times x}{3 \times 100}$ lbs.

Example

Weight of finisher delivery per 100 yds. ...	15·9 lbs.
Doublings on 1st. drawing frame ...	2 to 1
Draft on 1st. drawing frame ...	3·2
Number of deliveries per frame ...	4
Surface speed of drawing roller ...	120 f. p. m.
Doublings on 2nd. drawing frame ...	2 to 1
Draft on 2nd. drawing frame ...	5·4
Number of deliveries per frame ...	15
Surface speed of drawing roller ...	85 f. p. m.
Doublings on 3rd. drawing frame ...	2 to 1
Draft on 3rd. drawing frame ...	9
Number of deliveries per frame ...	20
Surface speed of drawing roller ...	140 f. p. m.

Weight of 1st. drawing delivery per 100 yds.

$$= \frac{15{\cdot}9 \times 2}{3{\cdot}2} = 9{\cdot}94 \text{ lbs.}$$

Production of 1st. drawing frame per day of 10 hours

$$= \frac{120 \times 60 \times 4 \times 9{\cdot}94 \times 10}{3 \times 100} = 9542{\cdot}40 \text{ lbs.}$$

Weight of 2nd. drawing delivery per 100 yds.

$$= \frac{9{\cdot}94 \times 2}{5{\cdot}4} = 3{\cdot}68 \text{ lbs.}$$

Production of 2nd. drawing frame per day of 10 hours

$$= \frac{85 \times 60 \times 15 \times 3{\cdot}68 \times 10}{3 \times 100} = 9384 \text{ lbs.}$$

Weight of 3rd. drawing delivery per 100 yds.

$$= \frac{3{\cdot}68 \times 2}{9} = 0{\cdot}82 \text{ lbs.}$$

Production of 3rd. drawing frame per day of 10 hours

$$= \frac{140 \times 60 \times 20 \times 0{\cdot}82 \times 10}{3 \times 100} = 4592 \text{ lbs.}$$

Can Packing and Turning Device

Usually the sliver from the first drawing frame is made into roll though can packers are in wide use. The can packers are commonly used to collect the sliver from the second and the third drawing frames. In can packing and turning device, the sliver drops in the can which is turning so that the sliver is evenly distributed in the can. Simultaneously a pressing device is employed to press the sliver at regular intervals for making room for maximum length of sliver in the can. The can is turned by placing it on a horizontal plate, revolving on a vertical axis by a suitable drive. The pressing device receives its up and down motion along a vertical shaft by another convenient drive.

Problesm

(i) Find the pitch of the screw that actuates the fallers in a spiral drawing frame from the following details :

Fallers per min.	...	320
Surface speed of drawing roller	...	78·5 f. p. m.
Draft on the frame	...	6
Lead of faller over retaining roller	...	2 %

Surface speed of retaining roller

$$=\frac{78{\cdot}5\times 12}{6}=157 \text{ inches per min.}$$

Surface speed of fallers

$$=157\times\frac{102}{100}=160{\cdot}14 \text{ inches per min.}$$

$$\text{Pitch of screw}=\frac{160{\cdot}14}{320}=0{\cdot}5 \text{ inch.}$$

(ii) In a first "Mackhigh" push bar drawing frame, the drawing roller makes 120 ft. per min. The draft on the frame is 3·2. The pitch of faller is $\frac{1}{2}$ inch and the lead of faller over retaining roller is 15%. Find the fallers per min.

Surface speed of retaining roller

$$=\frac{120 \times 12}{3\cdot 2}=450 \text{ inches per min.}$$

Surface speed of fallers

$$=450 \times \frac{120}{100}=540 \text{ inches per min.}$$

$$\text{Fallers per min.}=540 \div \frac{1}{2}=1080.$$

(iii) In a Mackie finisher screwgill triple cam drawing frame, faller surface speed is 195 inches per min. Lead of faller over retaining roller is 3·5%. Draft on the machine is 9. Find the drawing roller surface speed.

Retaining roller surface speed

$$=195 \times \frac{96\cdot 5}{100} \times \frac{1}{12}=15\cdot 68 \text{ f. p. m.}$$

Drawing roller surface speed

$$=15\cdot 68 \times 9=141\cdot 12 \text{ f. p. m.}$$

(iv) The draft constant of a Mackie push-bar first drawing frame (Mackhigh) is 0·10. A 40 teeth pinion is used as draft change pinion. The drawing roller which is 2·5 inches in diameter, makes 200 revs. per min. Find the surface speed of the retaining roller.

Draft = Draft Constant × Change Pinion

$$=0\cdot 10 \times 40=4$$

Surface speed of drawing roller

$$= 200 \times \frac{2{\cdot}5 \times 3{\cdot}14}{12} = 130{\cdot}83 \text{ f. p. m.}$$

Surface speed of retaining roller

$$= \frac{130{\cdot}83}{4} = 32{\cdot}71 \text{ f. p. m.}$$

(v) Find the weight of sliver from a second drawing frame in lbs. per 100 yds. from the following data :

Finisher card delivery per 100 yds.	10·02 lbs.
Doublings on first drawing frame	4 to 1
Draft on first drawing frame	4
Doublings on second drawing frame	2 to 1
Draft on second drawing frame	4·5

Weight of 2nd. drawing delivery per 100 yds.

$$= \frac{10{\cdot}02 \times 4}{4} \times \frac{2}{4{\cdot}5} = 4{\cdot}45 \text{ lbs.}$$

(vi) Calculate the weight of sliver per 14400 yds. from a 3rd. drawing frame from the following details :

Breaker card—dollop 30 lbs., clock length 13·1 yds., draft 12·5

Finisher card—doublings 10 to 1, draft 15

1st. drawing frame—doublings 8 to 1, draft 5

2nd. drawing frame—doublings 2 to 1, draft 5

3rd. drawing frame—doublings 1 to 1, draft 9

Allow 20% for wastage and evaporation of moisture.

$$\frac{30 \times 100}{13{\cdot}1} \times \frac{1}{12{\cdot}5} \times \frac{10}{15} \times \frac{8}{5} \times \frac{2}{5} \times \frac{1}{9} \times \frac{144}{1} \times \frac{80}{100} = 100 \text{ lbs.}$$

(vii) Calculate the production of a Mackie screwgill double cam second drawing frame in lbs. per hour under the following conditions :

5 heads per frame, 3 deliveries per head, doublings

2 to 1, first drawing frame sliver 10 lbs. per 100 yds., draft 5·4, speed of delivery 30 yds. per min., efficiency of the frame 75%, loss in weight 2%.

Weight of 2nd. drawing delivery per 100 yds.

$$= \frac{10 \times 2}{5 \cdot 4} \times \frac{98}{100} = 3 \cdot 63 \text{ lbs.}$$

Production per hour per delivery

$$= \frac{30 \times 60 \times 3 \cdot 63}{100} \times \frac{75}{100} = 49 \text{ lbs.}$$

Number of deliveries per frame $= 5 \times 3 = 15$

Production per hour per frame $= 49 \times 15 = 735$ lbs.

(viii) Calculate the production in cwts. per day of 16 hours of a five headed finisher drawing frame with 4 deliveries per head, delivering sliver that weighs 0·8 lb. per 100 yds. The delivery roller is 4 inches in diameter and runs at 140 revs. per min. Allow 25% for loss of time due to stoppages.

Delivery roller surface speed $= 140 \times \dfrac{4 \times 3 \cdot 14}{36}$

$= 48 \cdot 84$ yds./min.

Production per day per delivery

$$= \frac{48 \cdot 84 \times 60 \times 16 \times 0 \cdot 8}{100} = 375 \cdot 09 \text{ lbs.}$$

Number of deliveries per frame $= 5 \times 4 = 20$

Production per day per frame $= 375 \cdot 09 \times 20 = 7501 \cdot 80$ lbs.

Production per day per frame allowing

25% for loss of time $= \dfrac{7501 \cdot 80}{112} \times \dfrac{75}{100} = 50 \cdot 23$ cwts.

(ix) Calculate the dollop required to produce a 3rd. drawing frame delivery weighing 100 lbs. per 14400 yds. from the following data allowing 15% for loss in weight :

Breaker card—clock length 12 yds., draft 12
Finisher card—doublings 10 to 1, draft 12·5
1st. drawing frame – doublings 2 to 1, draft 3
2nd. drawing frame—doublings 2 to 1, draft 5
3rd. drawing frame—doublings 2 to 1, draft 10

$$\frac{\text{Dollop} \times 100}{12} \times \frac{1}{12} \times \frac{10}{12 \cdot 5} \times \frac{2}{3} \times \frac{2}{5} \times \frac{2}{10} \times \frac{144}{1} = 100 \text{ lbs.}$$

$$\text{Dollop} = \frac{12 \times 12 \times 12 \cdot 5 \times 3 \times 5 \times 10 \times 100}{100 \times 10 \times 2 \times 2 \times 2 \times 144} = 23 \cdot 44 \text{ lbs.}$$

Allowing 15% for loss in weight,

$$\text{Dollop} = 23 \cdot 44 \times \frac{115}{100} = 26 \cdot 96 \text{ lbs.}$$

CHAPTER VIII

THE ROVING FRAME

The Roving Frame and its Functions

The roving frame combines three distinct functions :

(i) A continuation of the process of attenuation of the sliver,

(ii) The introduction of a slight twist to the attenuated sliver to strengthen it and to assist uniform drawing during the operation of spinning,

(iii) The operation of winding the twisted sliver (rove) on to a bobbin.

A roving frame essentially is a drawing frame with a mechanism to twist the deliveries and to wind them separately on to bobbins. The drawing frame portion is usually of spiral type and consists of retaining rollers, fallers and drawing rollers. The spindles, bobbins and builder form the twisting and winding-on portion.

The bobbin must run either faster or slower than the flyer for building of twisted rove on the bobbin. If the bobbin and the flyer run at the same speed there will be no winding of rove on to the bobbin. Usually revolutions of the flyer is more than that of the bobbin. The spindle drive is direct. The bobbin drive involves the differential motion to obtain the relative speed of the bobbin for each traverse with respect to fixed speed of the spindle.

As the bobbin fills, its circumference increases. The delivery is constant. So the winding-on revolutions

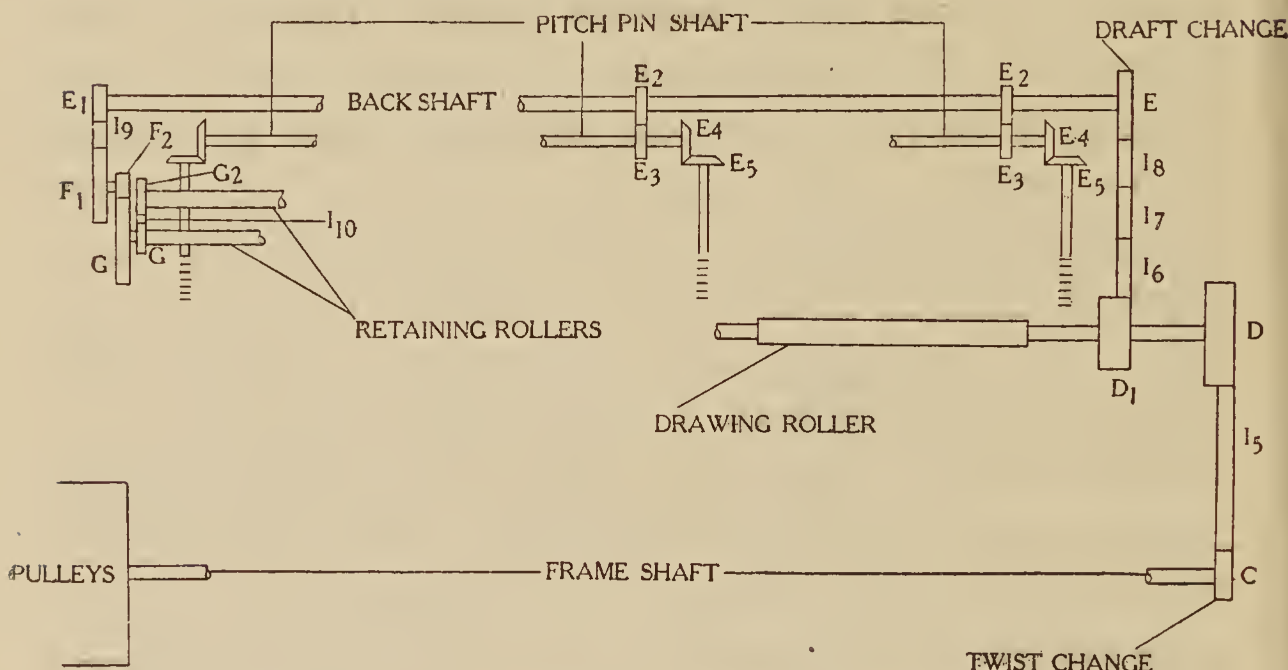
decrease. Again the spindle (i.e., flyer) speed is fixed. So the bobbin speed increases as the bobbin fills.

For uniform and compact filling of bobbins, the builder carrying the bobbins move upwards and downwards. The builder moves a distance equal to the diameter of the rove when one spiral of rove is wound on to a bobbin. The length of spiral on an empty bobbin at the beginning of a shift is much less than the length of spiral on a full bobbin towards the end of the shift. Thus the builder moves the distance equal to the diameter of the rove while a short spiral is delivered at the beginning of a shift and also the same distance when a longer spiral is delivered towards the end of the shift. The delivery being constant, the builder moves much more quickly at the beginning of the shift, speed changing with each layer put on. This variation in the speed of builder is controlled by the differential mechanism.

Drive to Drawing Frame Part—Speed Calculations

The frame shaft is driven from the driving shaft through drum, pulley and belting arrangement. The twist pinion C on the other end of the frame shaft, drives the drawing roller wheel D through a single intermediate I_5. The pinion D_1 on the drawing roller shaft drives the draft pinion E on the back shaft through three single intermediates I_6, I_7 and I_8. The pinion E_1 on the other end of the back shaft drives the retaining roller wheel G through a single intermediate I_9 and a double intermediate F_1/F_2. The pinion G_1 on the retaining roller shaft drives the back retaining roller wheel G_2 through a single

intermediate I_{10}. The pinion E_2 on the back shaft drives the pitch pin shaft wheel E_3. The bevel pinions E_4 on the pitch pin shaft drive the screw bevel pinions E_5.



Spiral Roving Frame—Drawing Frame Part

Driving shaft speed	...	A_1 r. p. m.
Diameter of drum	...	b inches
Diameter of pulley	...	b_1 ,,
Diameter of drawing roller	...	b_2 ,,
Diameter of retaining roller	...	b_3 ,,
Pitch of screw	...	c ,,

Frame shaft speed :

$$A_1 \times \frac{b}{b_1} \text{ r. p. m.}$$

Drawing roller speed :

$$A_1 \times \frac{b}{b_1} \times \frac{C}{D} \text{ r. p. m.}$$

$$A_1 \times \frac{b}{b_1} \times \frac{C}{D} \times \frac{b_2 \times 3{\cdot}14}{1} \text{ inches per min.}$$

Retaining roller speed :

$$A_1 \times \frac{b}{b_1} \times \frac{C}{D} \times \frac{D_1}{E} \times \frac{E_1}{F_1} \times \frac{F_2}{G} \text{ r. p. m.}$$

$$A_1 \times \frac{b}{b_1} \times \frac{C}{D} \times \frac{D_1}{E} \times \frac{E_1}{F_1} \times \frac{F_2}{G} \times \frac{b_3 \times 3{\cdot}14}{1}$$

inches per min.

Faller speed :

$$A_1 \times \frac{b}{b_1} \times \frac{C}{D} \times \frac{D_1}{E} \times \frac{E_2}{E_3} \times \frac{E_4}{E_5} \text{ drops per min.}$$

$$A_1 \times \frac{b}{b_1} \times \frac{C}{D} \times \frac{D_1}{E} \times \frac{E_2}{E_3} \times \frac{E_4}{E_5} \times \frac{c}{1} \text{ inches per min.}$$

$$\text{Draft Constant} = \frac{b_2 \times 3{\cdot}14}{D_1} \times \frac{1}{E_1} \times \frac{F_1}{F_2} \times \frac{G}{b_3 \times 3{\cdot}14} = e$$

Draft = Draft constant × Change pinion = $e \times E$

Lead of faller over retaining roller :

$$\frac{C}{E_5} \times \frac{E_4}{E_3} \times \frac{E_2}{E_1} \times \frac{F_1}{F_2} \times \frac{G}{b_3 \times 3{\cdot}14} = l \text{ times}$$

$\{(l \times 100) - 100\}\%$.

Example

Driving shaft speed	...	192	r.p.m.
Diameter of drum	...	30	inches
Diameter of pulley	...	24	,,
Pinion on off end of frame shaft (Twist change)		30	teeth
Drawing roller wheel	...	60	,,
Diameter of drawing roller	...	2·25	inches
Pinion on drawing roller (to retaining roller and faller)		34	teeth
Back shaft wheel (Draft change)		36	,,

Pinion on off end of back shaft (to retaining roller)		25 teeth
Double intermediate	...	68/25 ,,
Retaining roller wheel	...	69 ,,
Diameter of retaining roller	...	2 inches
Pinion on back shaft (to fallers)	...	22 teeth
Pitch pin shaft wheel	...	22 ,,
Pitch pin shaft bevel pinion	...	24 ,,
Bottom screw bevel pinion	...	16 ,,
Pitch of screw	...	$\frac{9}{16}$ inch

Frame shaft speed :

$$192 \times \frac{30}{24} = 240 \text{ r. p. m.}$$

Drawing roller speed :

$$192 \times \frac{30}{24} \times \frac{30}{60} = 120 \text{ r. p. m.}$$

$$120 \times \frac{2 \cdot 25 \times 3 \cdot 14}{12} = 70 \cdot 67 \text{ f. p. m.}$$

Retaining roller speed :

$$192 \times \frac{30}{24} \times \frac{30}{60} \times \frac{34}{36} \times \frac{25}{68} \times \frac{25}{69} = 15 \cdot 09 \text{ r. p. m.}$$

$$15 \cdot 09 \times \frac{2 \times 3 \cdot 14}{12} = 7 \cdot 9 \text{ f. p. m.}$$

Faller speed :

$$192 \times \frac{30}{24} \times \frac{30}{60} \times \frac{34}{36} \times \frac{22}{22} \times \frac{24}{16} = 170 \text{ drops per min.}$$

$$170 \times \frac{9}{16} = 95 \cdot 63 \text{ inches per min.}$$

$$\text{Draft Constant} = \frac{2 \cdot 25 \times 3 \cdot 14}{34} \times \frac{1}{25} \times \frac{68}{25} \times \frac{69}{2 \times 3 \cdot 14} = 0 \cdot 248$$

$$\text{Draft} = 0 \cdot 248 \times 36 = 8 \cdot 93$$

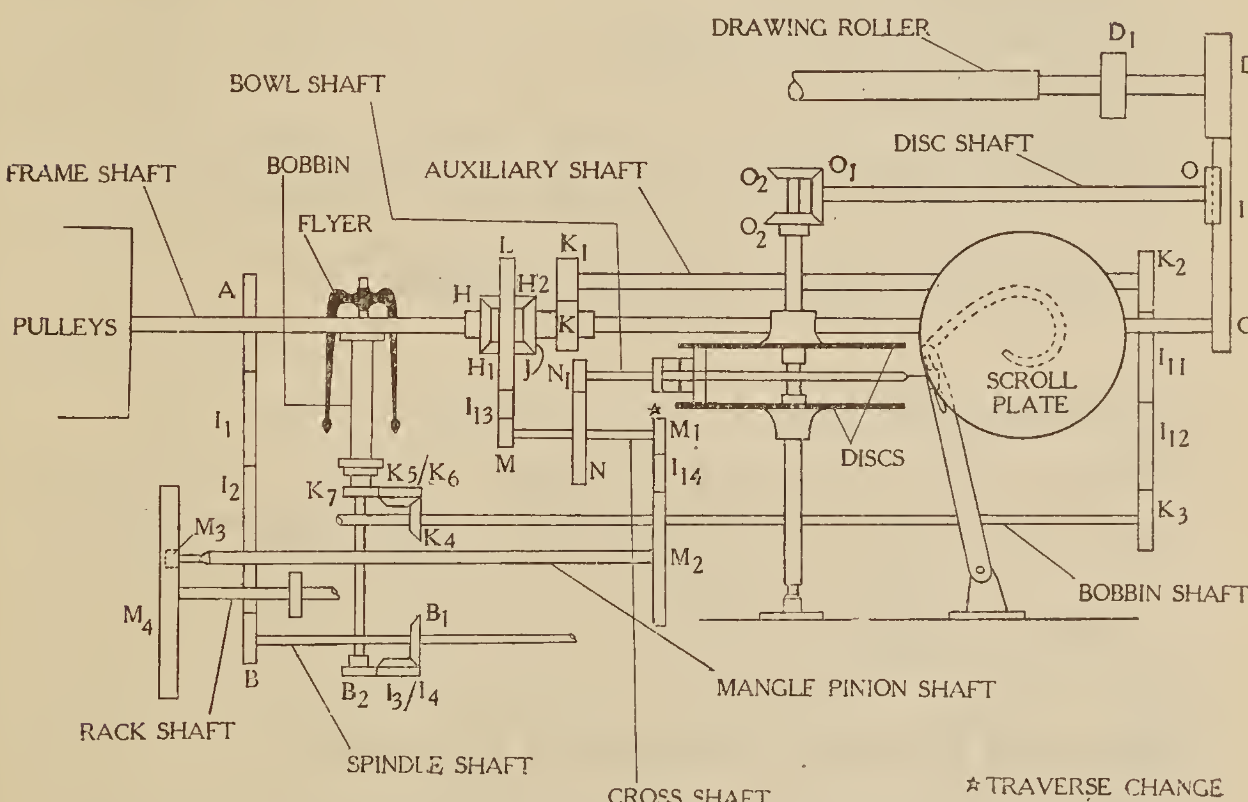
Lead of faller over retaining roller

$$= \frac{9}{16} \times \frac{1}{16} \times \frac{24}{22} \times \frac{22}{25} \times \frac{68}{25} \times \frac{69}{2 \times 3{\cdot}14} = 1{\cdot}0085 \text{ times}$$

$$= 1{\cdot}0085 \times 100 - 100 = 0{\cdot}85\%.$$

Drive to Spindle—Twist Calculations

The pinion A on the frame shaft, drives the spindle shaft wheel B through two single intermediates I_1 and I_2. The bevel pinion B_1 on the spindle shaft, drives the spindle driver B_2 through a crown wheel I_3/I_4 (acting as a single intermediate).



Roving Frame—Twisting and Winding-on Part

$$\text{Spindle speed} = A_1 \times \frac{b}{b_1} \times \frac{A}{B} \times \frac{B_1}{B_2} \text{ r. p. m.}$$

One revolution of the spindle imparts one turn of twist to the length of sliver delivered from the drawing roller

during the revolution. The degree of twist is usually expressed as turns per inch of rove.

$$\text{Turns per inch} = \frac{\text{r. p. m. of spindle}}{\text{inches per min. of drawing roller}}$$

$$\text{Twist Constant} = \frac{D}{1} \times \frac{A}{B} \times \frac{B_1}{B_2} \times \frac{1}{b_2 \times 3{\cdot}14} = f$$

$$\text{Twist} = \frac{\text{Twist constant}}{\text{Change pinion}} = \frac{f}{C}.$$

Example

Pinion on frame shaft (to spindle)	...	44 teeth
Spindle shaft wheel	...	22 ,,
Spindle shaft bevel pinion	...	21 ,,
Spindle driver	...	14 ,,

$$\text{Spindle speed} = 192 \times \frac{30}{24} \times \frac{44}{22} \times \frac{21}{14} = 720 \text{ r. p. m.}$$

$$\text{Turns per inch} = \frac{720}{70{\cdot}67 \times 12} = 0{\cdot}849$$

Twist Constant

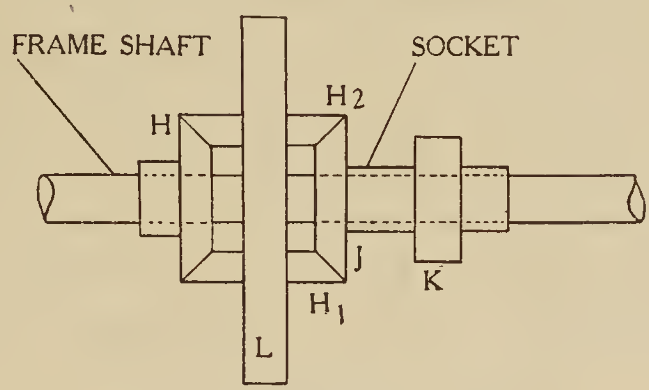
$$= \frac{60}{1} \times \frac{44}{22} \times \frac{21}{14} \times \frac{1}{2{\cdot}25 \times 3{\cdot}14} = 25{\cdot}46$$

$$\text{Twist} = \frac{25{\cdot}46}{30} = 0{\cdot}849.$$

Differential Wheel and Winding-On Mechanism

H, H_1, H_2 and J are all bevels of same size. The bevel H is fixed to the frame shaft. The centres of the bevels H_1 and H_2 are on the axis of the differential wheel L. The socket bevel J is fixed to a socket, running loosely on the frame shaft. The frame shaft imparts a speed equal to its own to the socket wheel. In jute industry the

differential wheel is driven in the direction of the frame shaft. The effect of the revolution of the differential wheel in the direction of the frame shaft is that each revolution



Differential Mechanism

it makes, reduces two revolutions from the speed of the socket wheel. Thus the socket wheel has less speed than the frame shaft. So the bobbins are driven with less speed than the flyers and this difference between the revolutions of bobbin and flyer gives the winding-on revolutions.

Bobbin Drive

Two trains of gearing drive the bobbin driver. The first drive is the direct drive. The second drive modifies the first drive at the commencement of each new layer on to the bobbin as the bobbin fills.

In the first drive, the sun wheel H drives the socket wheel J through the plannet wheels H_1 and H_2. The bobbin wheel K compounded with the socket wheel, drives the auxiliary shaft wheel K_1. The pinion K_2 on the other end of the auxiliary shaft, drives the bobbin shaft wheel K_3 through two single intermediates I_{11} and I_{12}. The bevels K_4 on the bobbin shaft, drive the bobbin drivers K_7 through the crown wheels K_5/K_6 acting as a single intermediate.

In the second drive, the drawing roller wheel D drives the disc shaft wheel O. The disc shaft bevel O_1 on the other end of the disc shaft, drives the disc bevels O_2. The top bevel is fixed on the shaft carrying the bottom disc and the bottom bevel on the socket carrying the top disc. The discs are thus driven in opposite directions. A bowl between the discs, is driven by them. The pinion N_1 on the other end of the bowl shaft, drives the cross shaft wheel N. The pinion M on one end of the cross shaft, drives the differential wheel L through a single intermediate I_{13}.

Differential wheel speed :

Drawing roller r. p. m.

$$\times \frac{D}{O} \times \frac{O_1}{O_2} \times \frac{g}{h} \times \frac{N_1}{N} \times \frac{M}{L} \text{ r. p. m.}$$

where, g = working diameter of discs in inches

h = diameter of bowl in inches.

Socket wheel speed :

Frame shaft r. p. m. $\times \frac{H}{J}$ − differential wheel r. p. m. × 2 r. p. m.

Bobbin speed :

Socket wheel r. p. m. $\times \frac{K}{K_1} \times \frac{K_2}{K_3} \times \frac{K_4}{K_7}$ r. p. m.

Example

Drawing roller speed	...	120 r. p. m.
Drawing roller wheel	...	60 teeth
Disc shaft wheel	...	30 ,,
Pinion on off end of disc shaft	...	28 ,,
Disc bevels	...	28 ,,
Working diameter of discs	...	8 inches

Diameter of bowl ...	5 inches
Pinion on off end of bowl shaft ...	20 teeth
Cross shaft wheel ...	96 ,,
Pinion on cross shaft (to differential wheel)	12 ,,
Differential wheel ...	78 ,,
Frame shaft speed ...	240 r. p.m.
Sun wheel ...	30 teeth
Socket wheel ...	30 ,,
Bobbin wheel ...	30 ,,
Auxiliary shaft wheel ...	24 ,,
Pinion on off end of auxiliary shaft	48 ,,
Bobbin shaft wheel ...	30 ,,
Bobbin shaft bevel ...	21 ,,
Bobbin driver ...	14 ,,

Differential wheel speed :

$$120 \times \frac{60}{30} \times \frac{28}{28} \times \frac{8}{5} \times \frac{20}{96} \times \frac{12}{78} = 12{\cdot}31 \text{ r. p. m.}$$

Socket wheel speed :

$$240 \times \frac{30}{30} - 12{\cdot}31 \times 2 = 215{\cdot}38 \text{ r. p. m.}$$

Bobbin speed :

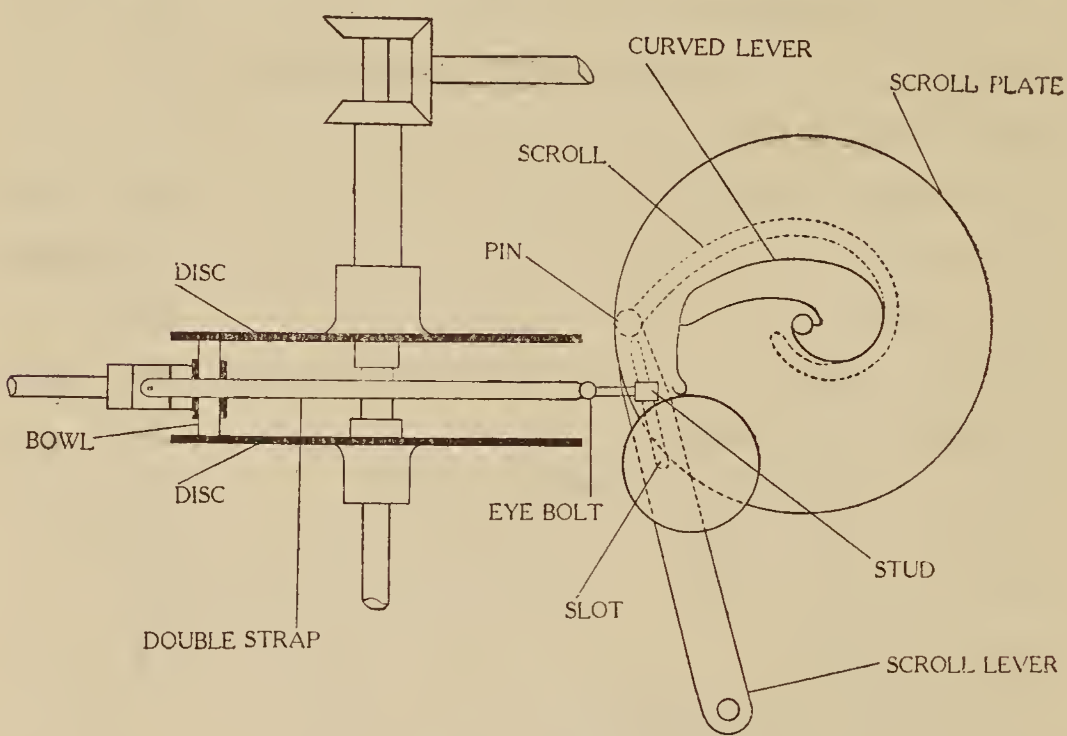
$$215{\cdot}38 \times \frac{30}{24} \times \frac{48}{30} \times \frac{21}{14} = 646{\cdot}14 \text{ r. p. m.}$$

Discs and Bowl, Scroll, Scroll Plate and Index Wheel

As each layer of rove is laid on the bobbin, the bowl between the discs is moved from the outside to the centre of the discs and by smaller amount each time.

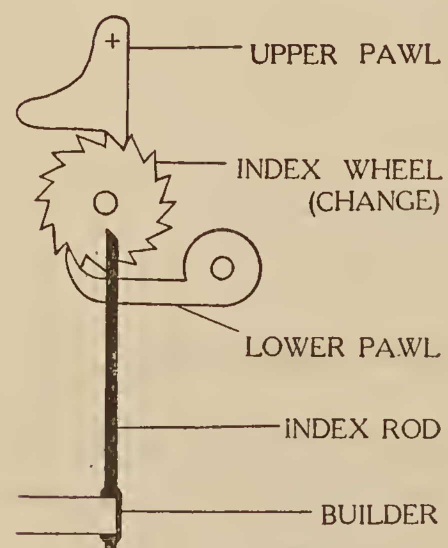
The bowl is connected to the stud fixed in a slot in the scroll lever by means of a double strap and an eye bolt. A pin at the top of the scroll lever is in contact with the

groove of the scroll cam. As the scroll plate rotates, the scroll pulls the pin towards the centre of the scroll plate



Disc and Scroll

at a decreasing speed. A weight connected to a curved lever on the outside of the plate by means of a chain, obtains the rotating motion of the scroll plate. The index wheel on the same shaft of the scroll plate, controls this movement of the scroll plate. Two pawls are geared with the index wheel. When one of them is geared with the wheel, the other rests at half-tooth. When the builder is at the highest position, the index rod which is attached to the builder, lifts the upper pawl and the scroll plate is rotated by the weight until the lower pawl



Index Mechanism

arrests the index wheel. When the builder is at the lowest position, the lower pawl is pushed out of contact with the index wheel by a projection of the index rod and the index wheel is moved a distance of half tooth until it is caught by the upper pawl. Thus for each traverse of the builder, the index wheel moves a distance equal to a half-tooth. The scroll plate on the same shaft moves correspondingly with the scroll. The scroll pulls the pin at the top of the scroll lever towards the centre of the scroll plate, thus moving the scroll lever and hence drawing the bowl towards the centre of the discs.

Builder Drive

The pinion M_1 on one end of the cross shaft, drives the mangle pinion shaft wheel M_2 through a single intermediate I_{14}. The mangle pinion M_3 on the other end of the mangle pinion shaft drives the mangle wheel M_4 on the rack shaft. The rack pinion on the rack shaft is geared with the rack.

The mangle wheel in conjunction with the rack arrangement, produces the up and down motion of the builder. The mangle pinion rotates in the same direction. When it is geared with the inside of the mangle wheel, it drives the wheel in the same direction as itself and when geared with the outside of the mangle wheel, it drives the wheel in the opposite direction. This change in the direction of movement of the mangle wheel, carrying the rack shaft and rack pinion along with it, causes the builder to move upwards and downwards.

8

The Filling of Bobbin and the Corresponding Changes

(i) The winding-on revs. decrease.
(ii) The bobbin speed increases.
(iii) The differential wheel speed decreases.
(iv) The bowl moves towards the centre of the discs.
(v) The builder speed decreases.

Some Points on Roving Calculations

(i) Flyer revs.—Bobbin revs. = Winding-on revs.

(ii) Winding-on revs. × Circumference of bobbin
= Winding-on motion
= Delivery

(iii) $\dfrac{\text{Delivery}}{\text{Circumference of bobbin}} = \text{Winding-on revs.}$

(iv) $\dfrac{\text{Spindle revs.}}{\text{Delivery in inches}} = \text{Turns per inch}$

(v) Working dia. of discs in inches × Corresponding dia. of bobbin in inches = 29·25.

Changing Sizes

(i) From the same sliver with same degree of twist :—

Rove weight per spyndle to be changed from W lbs. to W_1 lbs., W_1 being greater than W.

Draft pinion for W_1 lbs. rove	...	a teeth
Twist pinion ,, ,, ,,	...	b ,,
Traverse pinion ,, ,, ,,	...	c ,,
Index wheel ,, ,, ,,	...	d ,,

Draft pinion for W_1 lbs. rove :

Heavier rove—Less draft—Smaller draft pinion

$a \times \dfrac{W}{W_1}$ teeth.

Twist pinion for W_1 lbs. rove :

Heavier rove—Less turns per inch—Bigger twist pinion

$$b \times \frac{\sqrt{W_1}}{\sqrt{W}} \text{ teeth.}$$

Traverse pinion for W_1 lbs. rove :

Heavier rove—Bigger dia. of rove—More traverse—Bigger traverse pinion

$$c \times \frac{\sqrt{W_1}}{\sqrt{W}} \text{ teeth.}$$

Index wheel for W_1 lbs. rove :

Heavier rove—Bigger dia. of rove—Larger steps of bowl—Coarser wheel (fewer teeth)

$$d \times \frac{\sqrt{W}}{\sqrt{W_1}} \text{ teeth.}$$

Example

Draft pinion	for 72 lbs. rove		...	36	teeth
Twist pinion	,,	,, ,,	...	40	,,
Traverse pinion	,,	,, ,,	...	25	,,
Index wheel	,,	,, ,,	...	15	,,

Rove weight to be changed to 90 lbs. with the same degree of twist :

Draft pinion for 90 lbs. rove $= 36 \times \frac{72}{90} = 28{\cdot}8$ i.e., 29 teeth

Twist pinion ,, ,, ,, $= 40 \times \frac{\sqrt{90}}{\sqrt{72}} = 44{\cdot}7$ i.e., 45 teeth

Traverse pinion ,, ,, ,, $= 25 \times \frac{\sqrt{90}}{\sqrt{72}} = 27{\cdot}9$ i.e., 28 teeth

Index wheel ,, ,, ,, $= 15 \times \frac{\sqrt{72}}{\sqrt{90}} = 13{\cdot}4$ i.e., 13 teeth.

(ii) From different slivers and to have different turns per inch :—

Rove weight per spyndle to be changed from W lbs. to W_1 lbs., W_1 being greater than W.

W lbs. rove with e turns per inch and from x lbs. siiver per 100 yds.

W_1 lbs. rove with f turns per inch and from y lbs. sliver per 100 yds.

Draft pinion for W lbs. rove	...	a teeth
Twist pinion ,, ,, ,,	...	b ,,
Traverse pinion ,, ,, ,,	...	c ,,
Index wheel ,, ,, ,,	...	d ,,

Draft pinion for W_1 lbs. rove :

$$\text{Draft for } W \text{ lbs. rove} = \frac{x \times 144}{W} = p$$

$$\text{Draft for } W_1 \text{ lbs. rove} = \frac{y \times 144}{W_1} = q$$

where, q is less than p

Less draft—smaller draft pinion

$a \times \dfrac{q}{p}$ teeth.

Twist pinion for W_1 lbs. rove :

f is greater than e.

More turns per inch—smaller twist pinion

$b \times \dfrac{e}{f}$ teeth.

Traverse pinion and index wheel should be calculated in the same way as shown in (i).

Example

72 lbs. rove with 0·7 turns per inch and from 4 lbs. sliver per 100 yds.

90 lbs. rove with 0·8 turns per inch and from 4·5 lbs. sliver per 100 yds.

Draft pinion for 72 lbs. rove	...	36 teeth
Twist pinion ,, ,, ,,	...	40 ,,
Traverse pinion ,, ,, ,,	...	25 ,,
Index wheel ,, ,, ,,	...	15 ,,

Rove weight to be changed from 72 lbs. to 90 lbs.

Draft for 72 lbs. rove $= \dfrac{4 \times 144}{72} = 8$

Draft for 90 lbs. rove $= \dfrac{4{\cdot}5 \times 144}{90} = 7{\cdot}2$

Draft pinion for 90 lbs. rove $= 36 \times \dfrac{7{\cdot}2}{8}$

$= 32{\cdot}4$ i.e., 32 teeth

Twist pinion ,, ,, ,, $= 40 \times \dfrac{0{\cdot}7}{0{\cdot}8} = 35$ teeth

Traverse pinion ,, ,, ,, $= 25 \times \dfrac{\sqrt{90}}{\sqrt{72}} = 28$,,

Index wheel ,, ,, ,, $= 15 \times \dfrac{\sqrt{72}}{\sqrt{90}} = 13$,,

Roving Frame—Production Calculations

(i) Weight per 14400 yds. of rove :

Weight per 100 yds. of 2nd. drawing delivery		W_4 lbs.
Draft on roving frame	...	D_4

Weight of rove per 14400 yds. $= \dfrac{W_4 \times 144}{D_4} = W_5$ lbs.

(ii) Production of roving frame per day of x hours :

Surface speed of drawing roller	...	S_4 f.p.m.
Number of deliveries per frame	...	T_2

$$\text{Rove per hour} = \frac{S_4 \times 60 \times T_2}{3} \text{ yds.}$$

$$\text{Weight of rove per hour} = \frac{S_4 \times 60 \times T_2 \times W_5}{3 \times 14400} \text{ lbs.}$$

Production of roving frame per day of x hours

$$= \frac{S_4 \times 60 \times T_2 \times W_5 \times x}{3 \times 14400} \text{ lbs.}$$

Example

Weight of 2nd. drawing delivery per 100 yds.	...	4·45 lbs.
Draft on roving frame	...	9
Number of deliveries per frame	...	64
Surface speed of drawing roller	...	80 f. p. m.

$$\text{Weight of rove per 14400 yds.} = \frac{4{\cdot}45 \times 144}{9} = 71{\cdot}20 \text{ lbs.}$$

Production of roving frame per day of 10 hours

$$= \frac{80 \times 60 \times 64 \times 71{\cdot}20 \times 10}{3 \times 14400}$$

$$= 5063{\cdot}33 \text{ lbs.}$$

Problems

(i) In a spiral roving frame the drawing roller is 2·25 inches in dia. and makes 130 revs. per min. The draft constant of the frame is 0·258 and a pinion of 32 teeth is used as the draft pinion. Pitch of the screw is 0·56 inch and the lead of faller over retaining roller is 4%. Find the fallers per min.

$$\text{Drawing roller speed} = \frac{130 \times 2{\cdot}25 \times 3{\cdot}14}{12} = 76{\cdot}54 \text{ f. p. m.}$$

$$\text{Draft} = 0{\cdot}258 \times 32 = 8{\cdot}26$$

Retaining roller speed $= \dfrac{76 \cdot 54}{8 \cdot 26} = 9 \cdot 27$ f. p. m.

Faller speed $= 9 \cdot 27 \times \dfrac{104}{100} = 9 \cdot 64$ f. p. m.

Fallers per min. $= \dfrac{9 \cdot 64 \times 12}{0 \cdot 56} = 206 \cdot 57.$

(ii) In a roving frame the drawing roller is 2·25 inches in dia. ; the drawing roller wheel is of 60 teeth and the ratio of the spindle gear is 3 to 1. The twist on rove is 0·72 turns per inch. Calculate the twist constant of the roving frame.

$$\frac{60}{\text{Twist pinion}} \times \frac{3}{1} \times \frac{1}{2 \cdot 25 \times 3 \cdot 14} = 0 \cdot 72$$

Twist pinion $= \dfrac{60 \times 3}{2 \cdot 25 \times 3 \cdot 14 \times 0 \cdot 72} = 35 \cdot 38$ teeth

Twist constant $= 35 \cdot 38 \times 0 \cdot 72 = 25 \cdot 47.$

(iii) The spindle speed of a roving frame is 600 r.p.m. The twist on rove is 0·72 turns per inch. Find the bobbin revolutions per min. when the diameter of the bobbin is 4 inches.

Delivery $= \dfrac{600}{0 \cdot 72} = 833 \cdot 33$ inches per min.

Winding-on revs. $= \dfrac{833 \cdot 33}{4 \times 3 \cdot 14} = 66 \cdot 35$

Bobbin revs. per min. $= 600 - 66 \cdot 35 = 533 \cdot 65.$

(iv) The drawing roller of a roving frame makes 80 ft. per min. Calculate the time taken to fill a bobbin holding 3 lbs. when the weight of rove is 72 lbs. per spyndle.

72 lbs. = 14400 yds. of rove

3 lbs. $= \dfrac{14400 \times 3}{72} = 600$ yds. of rove

Time taken to fill the bobbin $= \dfrac{600 \times 3}{80} = 22 \cdot 5$ mins.

(v) Calculate the count of the rove in lbs. per spyndle when a 2nd. drawing sliver weighing 5·1 lbs. per 100 yds. is fed into a roving frame. The draft on the roving frame is 9. Allow 2% for loss in weight.

$$\frac{5{\cdot}1 \times 144}{9} \times \frac{98}{100} = 79{\cdot}97 \text{ lbs. per spyndle.}$$

(vi) Find the production of a roving frame of 56 spindles at 70% efficiency in lbs. per hour, producing rove of 72 lbs. per spyndle with a twist of 0·75 turns per inch. The spindles rotate at 800 revs. per min.

$$\frac{800 \times 60 \times 72 \times 56}{0{\cdot}75 \times 36 \times 14400} \times \frac{70}{100} = 348{\cdot}32 \text{ lbs. per hour.}$$

(vii) The draft constant and twist constant of a roving frame are 0·25 and 25·50 respectively. The draft and twist for 81 lbs. rove are 8 and 0·75 turns per inch respectively. What would be draft and twist pinions for 100 lbs. rove from the same sliver and with the same degree of twist ?

$$\text{Draft pinion for 81 lbs. rove} = \frac{8}{0{\cdot}25} = 32 \text{ teeth}$$

$$\text{Twist pinion for 81 lbs. rove} = \frac{25{\cdot}50}{0{\cdot}75} = 34 \text{ teeth}$$

$$\text{Draft pinion for 100 lbs. rove} = 32 \times \frac{81}{100}$$

$$= 25{\cdot}92 \text{ say } 26 \text{ teeth}$$

$$\text{Twist pinion for 100 lbs. rove} = 34 \times \frac{\sqrt{100}}{\sqrt{81}}$$

$$= 37{\cdot}77 \text{ say } 38 \text{ teeth.}$$

CHAPTER IX

THE SYSTEM

Usual Limitations

(i) Doublings :

Finisher card ... 10 to 1, 12 to 1 or 13 to 1

1st. drawing frame ... 2 to 1, 4 to 1 or 8 to 1

2nd. drawing frame ... 2 to 1 or 4 to 1

3rd. drawing frame ... 1 to 1 or 2 to 1

Roving frame ... 1 to 1

(ii) Drafts :

Breaker card ... 10 to 15

Finisher card ... 10 to 18

Push-bar drawing frame 3 to 5·5

Spiral drawing frame 5 to 10

Spiral roving frame 7 to 10

(iii) Fallers per minute :

Push-bar drawing frame 450 to 1050

Spiral drawing frame 250 to 550

Spiral roving frame 225 to 250

Standard Systems

(i) Rove spinning system (warp) :

2 Half-circular, 2-pair roller, single-doffer breaker cards ;

3 Half-circular, 3-pair roller, single-doffer finisher cards,

or

3 Full-circular, 4-pair roller, single-doffer finisher cards ;

3 Push-bar first drawing frames, 2 heads per frame, 1 delivery per head ;

3 Push-bar second drawing frames, 2 heads per frame, 2 deliveries per head,

or

3 Spiral second drawing frames, 2 heads per frame, 3 deliveries per head ;

3 Spiral roving frames, 64 deliveries per frame.

(ii) Rove spinning system (sacking weft) :

5 Half-circular, 2-pair roller, single-doffer breaker cards ;

6 Half-circular, 3-pair roller, single-doffer finisher cards ;

6 Push-bar first drawing frames, 2 heads per frame, 2 deliveries per head ;

6 Push-bar second drawing frames, 2 heads per frame, 2 deliveries per head ;

6 Spiral roving frames, 64 spindles per frame.

(iii) Sliver spinning system (warp) :

2 Half-circular, 2-pair roller, single-doffer breaker cards ;

3 Full-circular, 4-pair roller, double-doffer finisher cards ;

2 Push-bar first drawing frames, 2 heads per frame, 2 deliveries per head ;

2 Screwgill double cam second drawing frames, 5 heads per frame, 3 deliveries per head ;

4 Screwgill triple cam finisher drawing frames, 5 heads per frame, 4 deliveries per head.

(iv) Sliver spinning system (sacking weft) :

5 Half-circular, 2-pair roller, single-doffer breaker cards ;

6 Half-circular, 4-pair roller, single-doffer finisher cards ;

6 Push-bar first drawing frames, 2 heads per frame, 2 deliveries per head ;

6 Spiral second drawing frames, 4 heads per frame, 4 deliveries per head.

System Calculations

A	...	Dollop weight in lbs.
B	...	Clock length in yds.
C	...	Breaker card draft
D	...	Ends on finisher card
E	...	Finisher card draft
F	...	Doublings on first drawing frame
G	...	First drawing frame draft
H	...	Doublings on second drawing frame
I	...	Second drawing frame draft
J	...	Roving frame draft
K	...	Doublings on third (finisher) drawing frame
J_1	...	Finisher drawing frame draft

Breaker card feed per 100 yds. $= \frac{A \times 100}{B}$ lbs.

Breaker card delivery per 100 yds. $= \frac{A \times 100}{B} \times \frac{1}{C}$ lbs.

Finisher card delivery per 100 yds. $= \frac{A \times 100}{B} \times \frac{1}{C} \times \frac{D}{E}$ lbs.

First drawing frame delivery per 100 yds.

$$= \frac{A \times 100}{B} \times \frac{1}{C} \times \frac{D}{E} \times \frac{F}{G} \text{ lbs.}$$

Second drawing frame delivery per 100 yds.

$$= \frac{A \times 100}{B} \times \frac{1}{C} \times \frac{D}{E} \times \frac{F}{G} \times \frac{H}{I} \text{ lbs.}$$

Roving frame delivery per 100 yds.

$$= \frac{A \times 100}{B} \times \frac{1}{C} \times \frac{D}{E} \times \frac{F}{G} \times \frac{H}{I} \times \frac{1}{J} \text{ lbs.}$$

Roving frame delivery per spyndle

$$= \frac{A \times 100}{B} \times \frac{1}{C} \times \frac{D}{E} \times \frac{F}{G} \times \frac{H}{I} \times \frac{1}{J} \times \frac{144}{1} \text{ lbs.}$$

Finisher drawing frame delivery per 100 yds.

$$= \frac{A \times 100}{B} \times \frac{1}{C} \times \frac{D}{E} \times \frac{F}{G} \times \frac{H}{I} \times \frac{K}{J_1} \text{ lbs.}$$

Finisher drawing frame delivery per spyndle

$$= \frac{A \times 100}{B} \times \frac{1}{C} \times \frac{D}{E} \times \frac{F}{G} \times \frac{H}{I} \times \frac{K}{J_1} \times \frac{144}{1} \text{ lbs.}$$

Problems

(i) Calculate suitable drafts for the first drawing frame (push-bar) and the second drawing frame (spiral) to produce 90 lbs. rove per spyndle from a 32 lbs. dollop weight. The other details are as follows :

Clock length 13 yds., breaker card draft 12, doublings on finisher card 12 to 1, finisher card draft 15, doublings on first drawing frame 8 to 1, doublings on second drawing frame 2 to 1 and roving frame draft 9.

Assuming x as first drawing frame draft and y as second drawing frame draft,

$$\frac{32 \times 100}{13} \times \frac{1}{12} \times \frac{12}{15} \times \frac{8}{x} \times \frac{2}{y} \times \frac{1}{9} \times \frac{144}{1} = 90$$

$$x \times y = \frac{32 \times 100 \times 12 \times 8 \times 2 \times 144}{13 \times 12 \times 15 \times 9 \times 90} = 46{\cdot}68$$

Taking the value of x as 5·5, $y = \dfrac{46{\cdot}68}{5{\cdot}5} = 8{\cdot}49$.

(ii) The finisher card delivery weighs 16 lbs. per 100 yds. The doublings on first drawing frame, second drawing frame and finisher drawing frame are 2 to 1. The drafts on first drawing frame and second drawing frame are 3·2 and 5·4 respectively. Find the draft on finisher drawing frame to produce a sliver weighing 7·6 lbs. per 1000 yds. allowing 2% loss in weight in each of the drawing frames.

$$\frac{16\times 2}{3{\cdot}2}\times\frac{98}{100}\times\frac{2}{5{\cdot}4}\times\frac{98}{100}\times\frac{2}{x}\times\frac{98}{100}\times\frac{10}{1}=7{\cdot}6$$

where x = finisher drawing frame draft.

$$x=\frac{16\times 2\times 98\times 2\times 98\times 2\times 98\times 10}{3{\cdot}2\times 100\times 5{\cdot}4\times 100\times 100\times 7{\cdot}6}=9{\cdot}17.$$

(iii) A system of 2 breaker cards, 3 finisher cards, 3 first drawing frames (push-bar), 3 second drawing frames (spiral) and 3 roving frames (spiral), is employed to produce 0·5 ton of rove per hour. The count of the rove is 70 lbs. per spyndle. 10% is allowed for wastage and evaporation of moisture during the process. Other details are as follows :

Breaker card—clock length 13 yds., 1 delivery, dia. of drawing roller 4 inches ;

Finisher card—1 delivery, dia. of drawing roller 4 inches ;

1st. drawing frame—2 deliveries, pitch of faller $\frac{7}{8}$ inch, dia. of drawing roller 2·5 inches ;

2nd. drawing frame—6 deliveries, pitch of screw $\frac{4}{7}$ inch, dia. of drawing roller 2·5 inches ;

Roving frame—64 deliveries, pitch of screw $\frac{1}{2}$ inch,

dia. of drawing roller 2·25 inches, twist 0·75 turns per inch. It is required to find

(a) dollop weight,
(b) weight of sliver per 100 yds. from each machine,
(c) drawing roller r. p. m. of each machine,
(d) fallers per min. of drawing and roving frames,
(e) spindle r. p. m. of roving frame.

(a) Let us suppose within practical limits the following details :

breaker card draft 10, doublings on finisher card 10 to 1, finisher card draft 12, doublings on first drawing frame 4 to 1, first drawing frame draft 4, doublings on second drawing frame 2 to 1, second drawing frame draft 8, roving frame draft 8.

$$\frac{\text{Dollop weight} \times 100}{13} \times \frac{1}{10} \times \frac{10}{12} \times \frac{4}{4} \times \frac{2}{8} \times \frac{1}{8} \times \frac{144}{1} \times \frac{90}{100}$$

$$= 70$$

$$\text{Dollop weight} = \frac{13 \times 10 \times 12 \times 4 \times 8 \times 8 \times 100 \times 70}{100 \times 10 \times 4 \times 2 \times 144 \times 90}$$

$$= 26{\cdot}96 \text{ lbs.}$$

(b) Breaker card delivery per 100 yds.

$$= \frac{26{\cdot}96 \times 100}{13} \times \frac{1}{10} = 20{\cdot}74 \text{ lbs.}$$

Finisher card delivery per 100 yds.

$$= \frac{20{\cdot}74 \times 10}{12} = 17{\cdot}28 \text{ lbs.}$$

First drawing frame delivery per 100 yds.

$$= \frac{17{\cdot}28 \times 4}{4} = 17{\cdot}28 \text{ lbs.}$$

Second drawing frame delivery per 100 yds.

$$=\frac{17{\cdot}28\times 2}{8}=4{\cdot}32 \text{ lbs.}$$

Roving frame delivery per 100 yds.

$$=\frac{4{\cdot}32}{8}=0{\cdot}54 \text{ lb.}$$

Weight of rove per spyndle allowing 10% for wastage

$$=\frac{0{\cdot}54\times 144\times 90}{100}=70 \text{ lbs.}$$

(c) Delivery per hour per breaker card $=\dfrac{0{\cdot}5 \text{ ton}}{2}=5$ cwt.

„ „ „ „ finisher card $=\dfrac{0{\cdot}5 \text{ ton}}{3}=3{\cdot}3$ „

„ „ „ „ 1st. drawing frame

$$=\frac{0{\cdot}5 \text{ ton}}{3}=3{\cdot}3 \text{ „}$$

„ „ „ „ 2nd. drawing frame

$$=\frac{0{\cdot}5 \text{ ton}}{3}=3{\cdot}3 \text{ „}$$

„ „ „ „ roving frame

$$=\frac{0{\cdot}5 \text{ ton}}{3}=3{\cdot}3 \text{ „}$$

$$\frac{R\times 4\times 3{\cdot}14}{36}\times\frac{1}{100}\times\frac{20{\cdot}74}{1}\times\frac{1}{112}\times\frac{60}{1}=\frac{5}{1}$$

where R = breaker card drawing roller r. p. m.

$$R=\frac{36\times 100\times 112\times 5}{4\times 3{\cdot}14\times 20{\cdot}74\times 60}\doteq 128{\cdot}98$$

Allowing 10% for loss in weight,

Drawing roller r. p. m. $=128{\cdot}98\times\dfrac{100}{90}=143{\cdot}31$

Finisher card drawing roller r.p.m.

$$= \frac{143{\cdot}31}{1} \times \frac{3{\cdot}3}{5} \times \frac{4}{4} \times \frac{12}{10} = 114{\cdot}64$$

First drawing frame drawing roller r.p.m.

$$= \frac{114{\cdot}64}{1} \times \frac{3{\cdot}3}{3{\cdot}3} \times \frac{4}{2{\cdot}5} \times \frac{4}{4} \times \frac{1}{2} = 91{\cdot}71$$

Second drawing frame drawing roller r.p.m.

$$= \frac{91{\cdot}71}{1} \times \frac{3{\cdot}3}{3{\cdot}3} \times \frac{2{\cdot}5}{2{\cdot}5} \times \frac{8}{2} \times \frac{2}{6} = 122{\cdot}28$$

Roving frame drawing roller r.p.m.

$$= \frac{122{\cdot}28}{1} \times \frac{3{\cdot}3}{3{\cdot}3} \times \frac{2{\cdot}5}{2{\cdot}25} \times \frac{8}{1} \times \frac{6}{64} = 101{\cdot}90$$

Allowing 10% for loss due to stoppages,

Breaker card drawing roller r.p.m.

$$= \frac{143{\cdot}31 \times 100}{90} = 159{\cdot}23$$

Finisher card drawing roller r.p.m.

$$= \frac{114{\cdot}64 \times 100}{90} = 127{\cdot}38$$

Allowing 20% for loss due to stoppages,

First drawing frame drawing roller r.p.m.

$$= \frac{91{\cdot}71 \times 100}{80} = 114{\cdot}64$$

Second drawing frame drawing roller r.p.m

$$= \frac{122{\cdot}28 \times 100}{80} = 152{\cdot}85$$

Allowing 25% for loss due to stoppages,

Roving frame drawing roller r.p.m.

$$= \frac{101{\cdot}90 \times 100}{75} = 135{\cdot}87$$

(d) Fallers per min. of first drawing frame allowing

$$10\%\ \text{lead} = \frac{114{\cdot}64 \times 2{\cdot}5 \times 3{\cdot}14}{4} \times \frac{110}{100} \times \frac{8}{7} = 282{\cdot}76$$

Fallers per min. of second drawing frame allowing

$$2\%\ \text{lead} = \frac{152{\cdot}85 \times 2{\cdot}5 \times 3{\cdot}14}{8} \times \frac{102}{100} \times \frac{7}{4} = 267{\cdot}72$$

Fallers per min. of roving frame allowing 2% lead

$$= \frac{135{\cdot}87 \times 2{\cdot}25 \times 3{\cdot}14}{8} \times \frac{102}{100} \times \frac{2}{1} = 244{\cdot}77$$

(e) Spindle r.p.m. of roving frame

$$= 135{\cdot}87 \times 2{\cdot}25 \times 3{\cdot}14 \times 0{\cdot}75 = 720{\cdot}60.$$

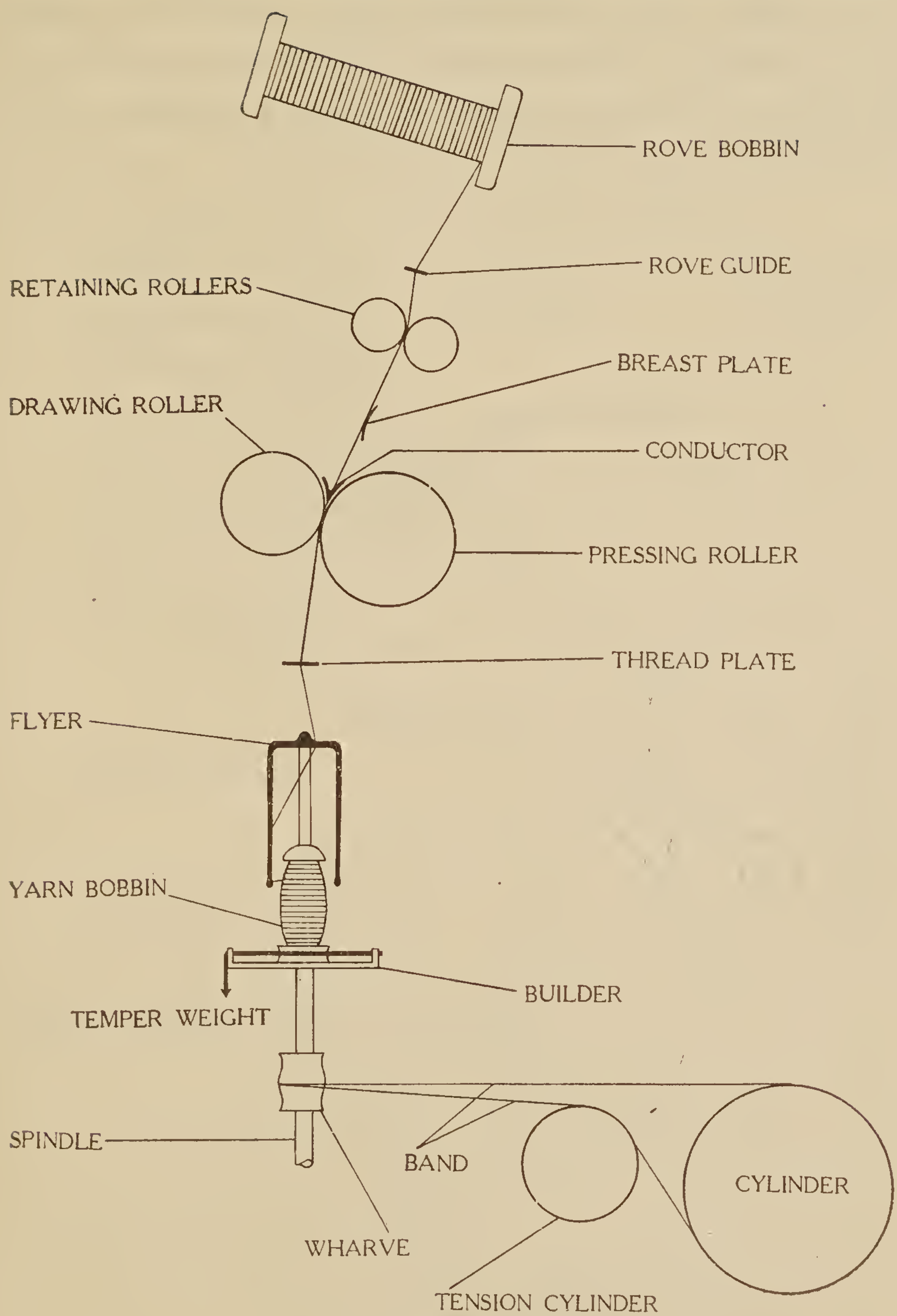
CHAPTER X

THE SPINNING FRAME

The Rove Spinning Frame

In the process of spinning, the rove is drawn and twisted to form what is known as yarn. The yarn is finally wound on to a bobbin.

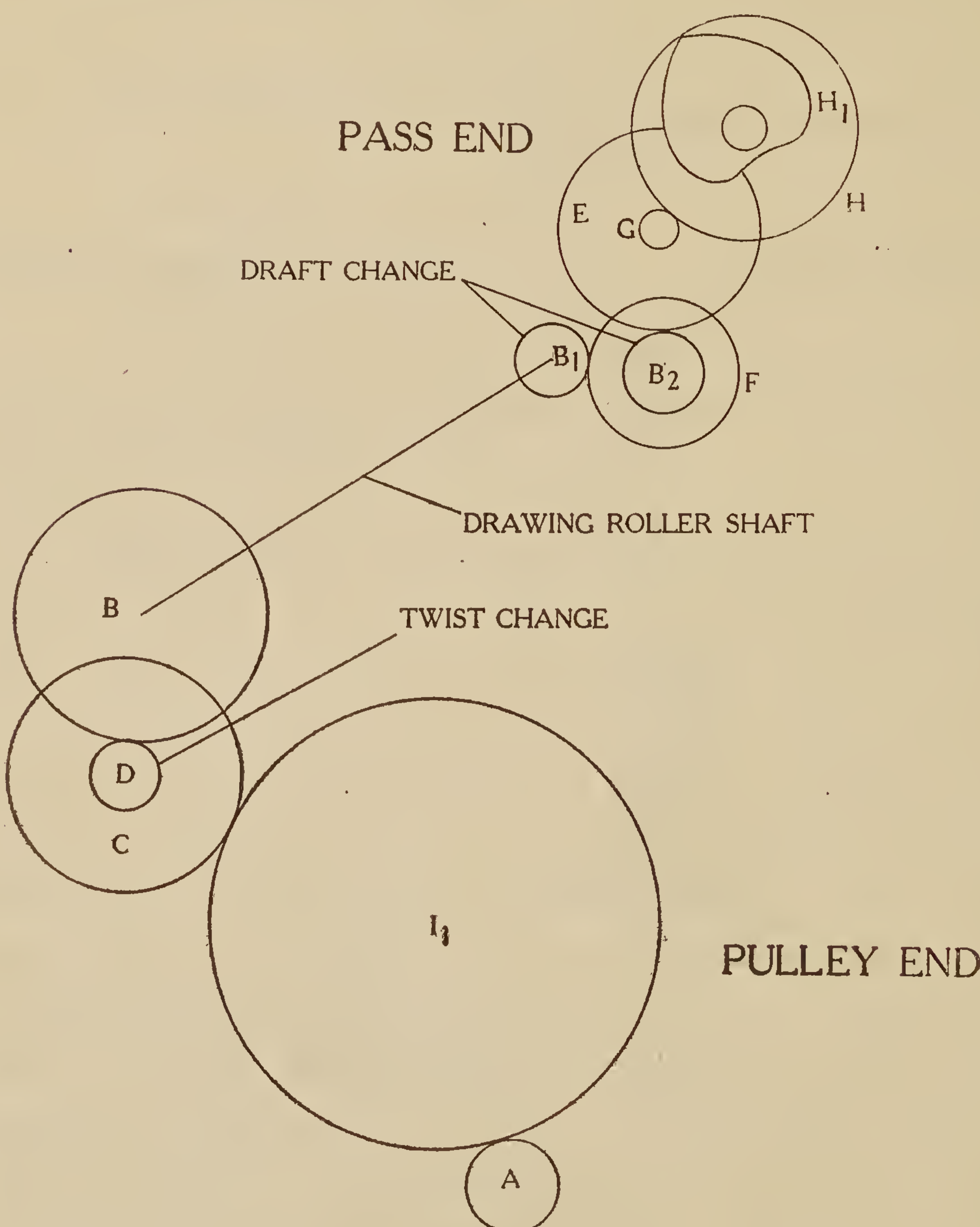
The rove from the rove bobbin placed at the creel, passes through the rove guide and then between the retaining rollers. The rove then passes over the breast plate. The breast plate when properly adjusted, keeps the twist on the rove as long as necessary and allows the untwisting to the extent necessary for even drawing out of the rove. After this the tin conductor guides the rove between the drawing roller and the pressing roller. The rove is drawn out between the retaining rollers and the drawing rollers and then passes tot he flyer. The revolutions of the flyer impart twist to the drawn out rove. The twisted material finally, passes to the shank of the spinning bobbin. The dragging action of the temper band and weight on the bobbin, controls the bobbin speed and thus the winding-on motion is obtained. The uniform up and down motion of the builder [illegible]ing the bobbins, builds the yarn on the bobbin.



Rove Spinning Frame

Spinning Frame Gearing—Speed Calculations

The drum on the driving shaft drives the pulley through belting. The cylinder pinion A on the pulley shaft, drives the drawing roller wheel B through a single



Spinning Frame Gearing

intermediate I_1 and a double intermediate (twist compound) C/D. The pinion B_1 on the other end of the

drawing roller, drives the retaining roller wheel E through a double intermediate F/B_2. The pinion G on the retaining roller, drives the heart cam wheel H. The heart cam H_1 drives the builder through a lever and connections. The spindles are driven from the cylinder by means of bands acting on the spindle wharves.

Driving shaft speed	...	A_1 r. p. m.
Diameter of drum	...	b inches
Diameter of pulley	...	c ,,
Diameter of cylinder	...	d ,,
Diameter of spindle wharve	...	e ,,
Diameter of drawing roller	...	f ,,
Diameter of retaining roller	...	g ,,

Cylinder speed :

$$A_1 \times \frac{b}{c} \text{ r. p. m.}$$

Spindle speed :

$$A_1 \times \frac{b}{c} \times \frac{d}{e} \text{ r. p. m.}$$

Drawing roller speed :

$$A_1 \times \frac{b}{c} \times \frac{A}{C} \times \frac{D}{B} \text{ r. p. m.}$$

$$A_1 \times \frac{b}{c} \times \frac{A}{C} \times \frac{D}{B} \times \frac{f \times 3{\cdot}14}{12} = h \text{ f. p. m.}$$

Retaining roller speed :

$$A_1 \times \frac{b}{c} \times \frac{A}{C} \times \frac{D}{B} \times \frac{B_1}{F} \times \frac{B_2}{E} \text{ r. p. m.}$$

$$A_1 \times \frac{b}{c} \times \frac{A}{C} \times \frac{D}{B} \times \frac{B_1}{F} \times \frac{B_2}{E} \times \frac{g \times 3{\cdot}5}{12} = i \text{ f. p. m.}$$

To allow for the fluting of the roller, the circumference of the retaining roller is taken as diameter × 3·5.

$$\text{Draft} = \frac{h}{i} = j$$

$$\text{Draft constant} = \frac{f \times 3{\cdot}14}{1} \times \frac{F}{B_2} \times \frac{E}{g \times 3{\cdot}5} = k$$

$$\text{Draft} = \frac{\text{Draft constant}}{\text{Change pinion}} = \frac{k}{B_1} = j$$

$$\text{Twist Constant} = \frac{B}{1} \times \frac{C}{A} \times \frac{d}{e} \times \frac{1}{f \times 3{\cdot}14} = l$$

$$\text{Twist} = \frac{\text{Twist constant}}{\text{Change pinion}} = \frac{l}{D}$$

Example

Driving shaft speed	...	205 r. p. m.
Diameter of drum	...	43 inches
Diameter of pulley	...	14 ,,
Diameter of cylinder	...	9 ,,
Diameter of spindle wharve	...	2 ,,
Cylinder pinion	...	20 teeth
Double intermediate (Twist change)		90/43 ,,
Drawing roller wheel	...	120 ,,
Diameter of drawing roller	...	4·25 inches
Pinion on off end of drawing roller (draft change)	...	31 teeth
Double intermediate	...	70/34 ,,
Retaining roller wheel	...	80 ,,
Diameter of retaining roller	...	2·5 inches

Cylinder speed :

$$205 \times \frac{43}{14} = 629{\cdot}64 \text{ r. p. m.}$$

Spindle speed :

$$629{\cdot}64 \times \frac{9}{2} = 2833{\cdot}38 \text{ r. p. m.}$$

Drawing roller speed :

$$629{\cdot}64 \times \frac{20}{90} \times \frac{43}{120} = 50{\cdot}138 \text{ r. p. m.}$$

$$50{\cdot}138 \times \frac{4{\cdot}25 \times 3{\cdot}14}{12} = 55{\cdot}76 \text{ f. p. m.}$$

Retaining roller speed :

$$50{\cdot}138 = \frac{31}{70} \times \frac{34}{80} = 9{\cdot}44 \text{ r. p. m.}$$

$$9{\cdot}44 \times \frac{2{\cdot}5 \times 3{\cdot}5}{12} = 6{\cdot}88 \text{ f. p. m.}$$

$$\text{Draft} = \frac{55{\cdot}76}{6{\cdot}88} = 8{\cdot}1$$

$$\text{Draft constant} = \frac{4{\cdot}25 \times 3{\cdot}14}{1} \times \frac{70}{34} \times \frac{80}{2{\cdot}5 \times 3{\cdot}5} = 251{\cdot}20$$

$$\text{Draft} = \frac{251{\cdot}20}{31} = 8{\cdot}1$$

$$\text{Twist constant} = \frac{120}{1} \times \frac{90}{20} \times \frac{9}{2} \times \frac{1}{4{\cdot}25 \times 3{\cdot}14} = 182{\cdot}09$$

$$\text{Twist} = \frac{182{\cdot}09}{43} = 4{\cdot}23 \text{ turns per inch}$$

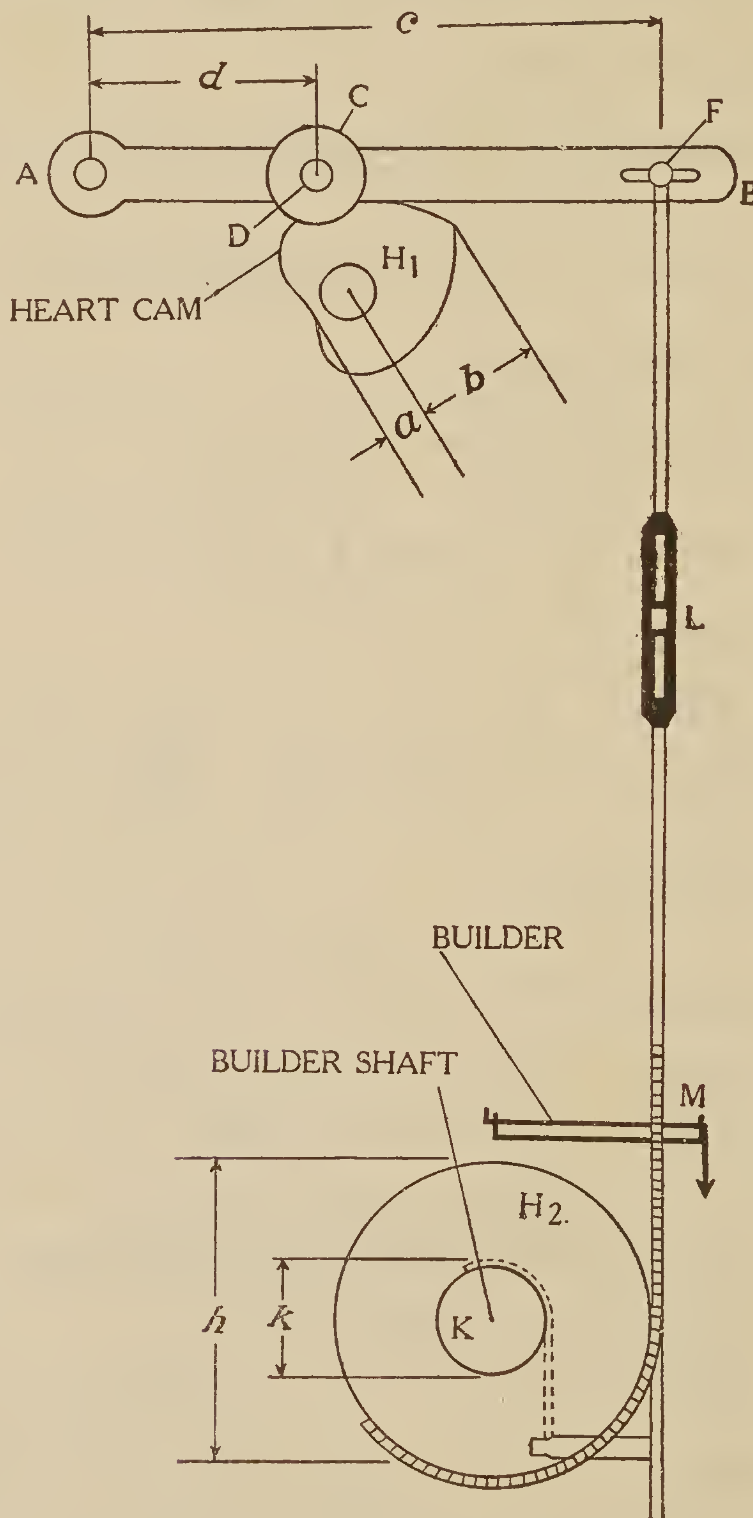
$$\text{Twist} = \frac{\text{Spindle speed r. p. m.}}{\text{Drawing roller speed inches per min.}}$$

$$= \frac{2833{\cdot}38}{55{\cdot}76 \times 12} = 4{\cdot}23 \text{ turns per inch.}$$

Builder Motion

The shape of the heart cam is such that the bowl C on the lever AB which is hinged at A, is moved up and down at a uniform rate. The length of the travel is

equal to the difference between the longest and shortest radii of the cam. Thus the lever is moved up and down



Spinning Frame—Builder Drive

and this motion is turned into the backward and forward

motion of the pulley H_2 through the connecting rod L and the chain M. The pulley H_2 is keyed to the builder shaft. The builder shaft thus rotates backward and forward. The pulleys K and the chains connecting them in conjunction with the builder bracket, convert this movement of the builder shaft into the up and down movement of the builder.

Shortest radius of the heart cam H_1	...	a	inches
Longest „ „ „ „ „ „	...	b	„
Travel of bowl C	...	$b-a$	„
Distance between A and F	...	c	„
Distance between A and D	...	d	„
Diameter of pulley H_2	...	h	„
Diameter of pulley K	...	k	„

$$\text{Builder traverse} = (b-a) \times \frac{c}{d} \times \frac{k}{h} \text{ inches}$$

The length of traverse may be altered to suit different sizes of bobbin. The length of traverse is increased when F is shifted further out or D further in. F is shifted further in or D further out to decrease the length of traverse. The change in the diameter of the pulley H_2 also alters the length of traverse.

Example

Shortest radius of the heart cam	...	1·5	inches
Longest radius of the heart cam	...	6·5	„
Distance between A and F	...	24	„
Distance between A and D	...	10	„
Diameter of pulley H_2	...	10	„
Diameter of pulley K	...	3·75	„

$$\text{Builder traverse} = (6{\cdot}5 - 1{\cdot}5) \times \frac{24}{10} \times \frac{3{\cdot}75}{10} = 4{\cdot}5 \text{ inches.}$$

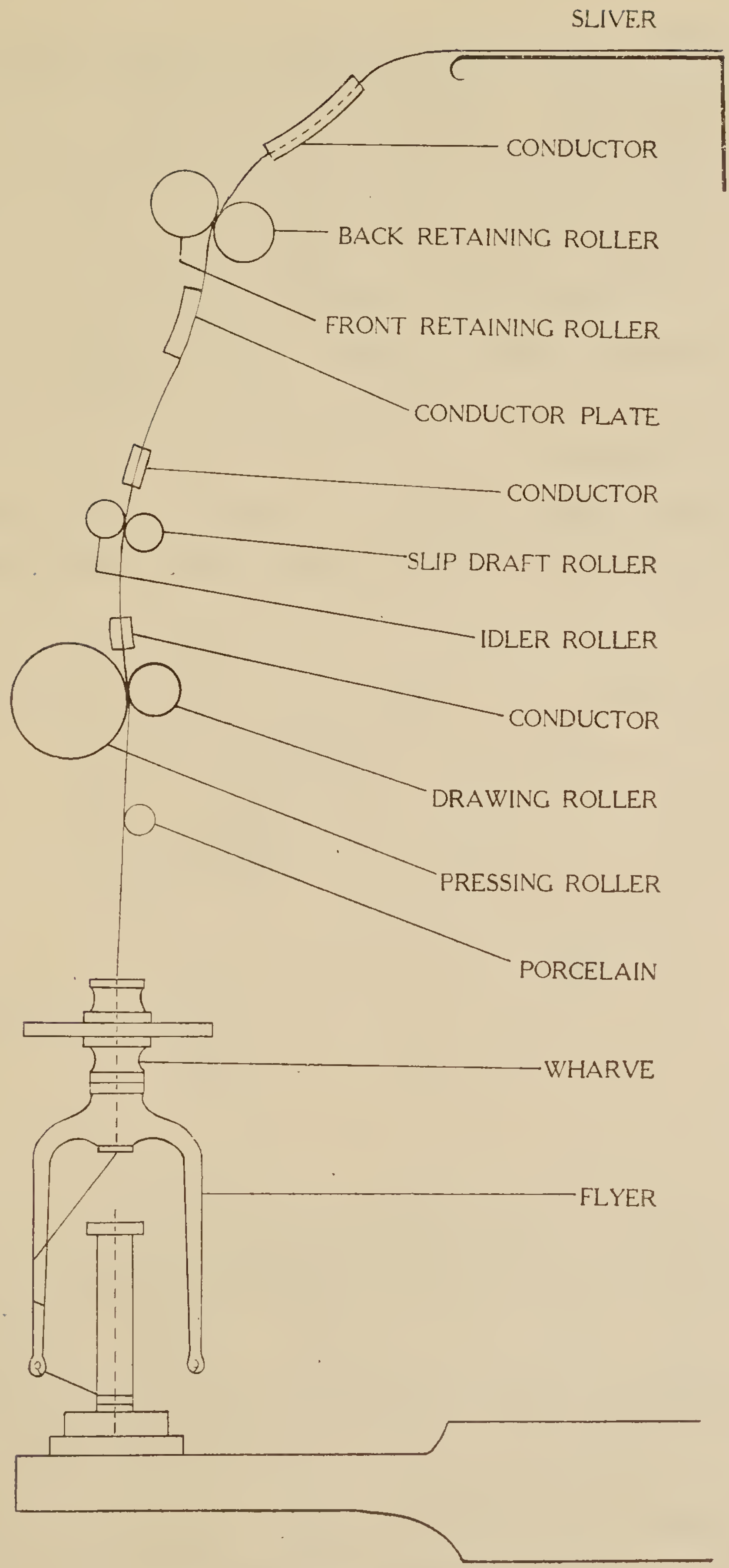
To change the traverse from 4·5 to 4, the diameter of the pulley H_2 should be altered to $\frac{10 \times 4{\cdot}5}{4} = 11{\cdot}25$ inches.

The Sliver Spinning (Slip Draft) Frame

The sliver from the finisher drawing frame are fed to the sliver spinning frame where it is drafted, twisted and finally wound on to a bobbin.

In a sliver spinning frame (Mackie $4\frac{1}{4}''$ pitch) the sliver is fed from a sliver can at the back of the machine. The sliver is led over the top of the machine, through a conductor and between the retaining rollers. The sliver, then, passes along the back of a conductor plate, through a conductor, between the slip draft roller and the idler roller, through another conductor and is finally drawn by the drawing rollers. The drawn-out sliver passes over the porcelain roller and then to the flyer through a hole on the top of the wharve. The revolutions of the flyer impart twist to the drawn-out sliver. The twisted sliver is finally wound on to a bobbin.

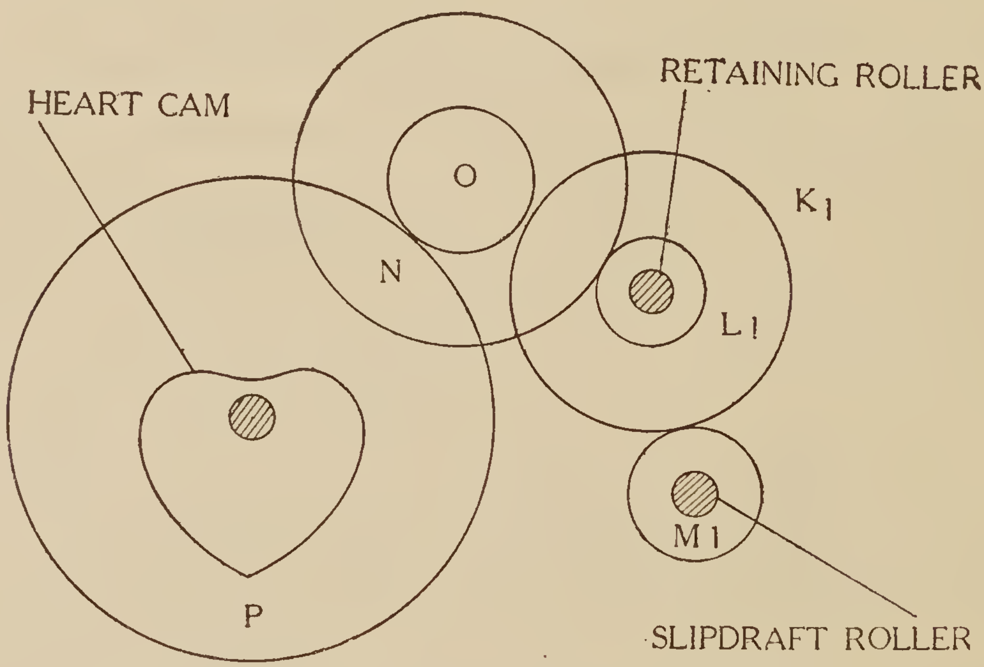
When the yarn breaks, the porcelain roller comes forward and causes a weight at the top of the machine to fall down by suitable lever arrangement. A knife attached to this weight, presses the back retaining roller out of contact with the front retaining roller thus stopping the intake of sliver. This automatic stop motion of the sliver prevents breakages of adjacent yarns when one yarn breaks.



Sliver Spinning Frame (Mackie)

The bobbin is placed on a hollow spindle fixed to the bobbin carrier plate. The bottom of this plate is provided with felt friction bobs. The dragging action of these bobs, controls the bobbin speed to obtain the winding-on motion. These bobs may be shifted inward or outward to reduce or increase the friction. The hollow spindle with the bobbin, revolves round a dead spindle which is fixed to the base plate. The base plate is attached to the bobbin board rail.

An electric motor conveys the motion to the spinning frame through "lenix" drive. The motor pulley and the

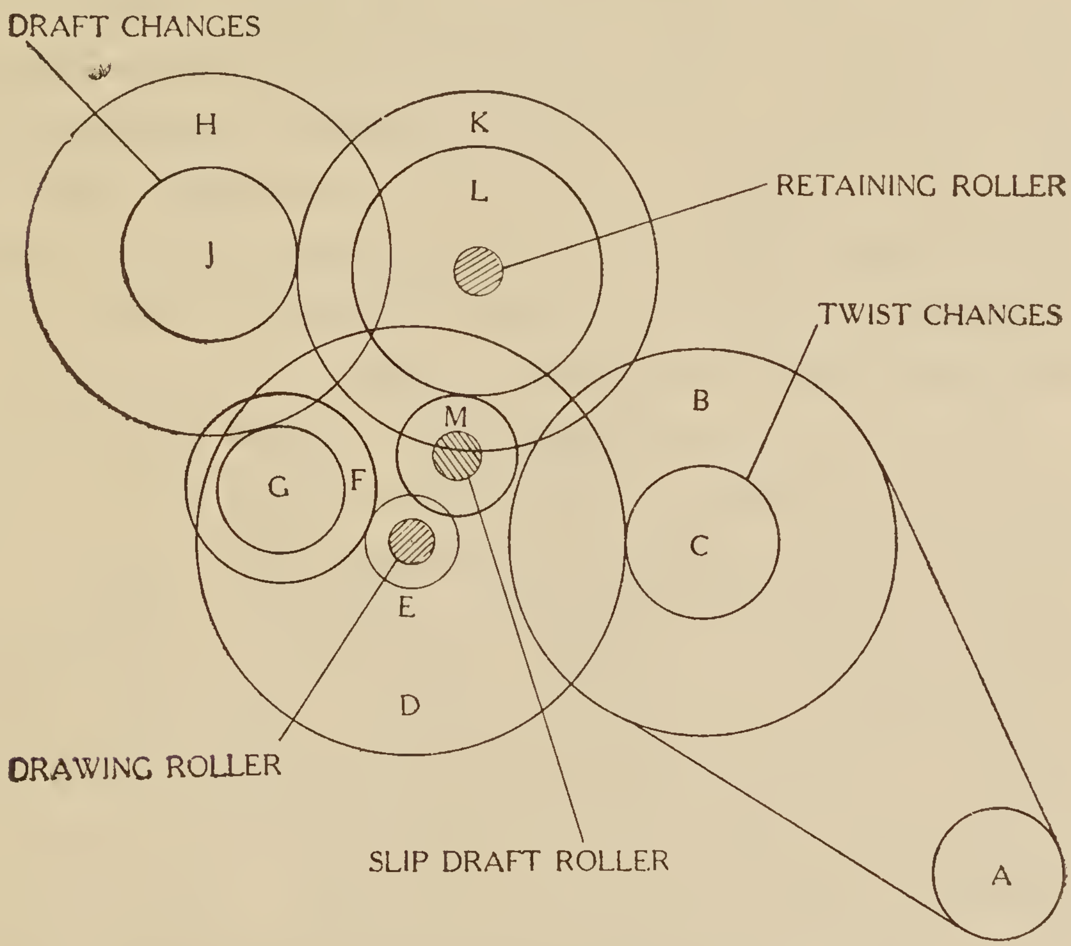


Sliver Spinning (Mackie) Gearing—Pulley side

machine pulley are connected by a loose belt and another tension pulley presses the belt tightly causing the belt to grip the pulleys. When the tension pulley is withdrawn from the belt, the grip is lost and the spinning frame stops.

The cylinder on the pulley shaft, drives the flyers by means of cotton listing acting on the flyer wharves. A

sprocket pinion A on the other end of the cylinder shaft, drives the drawing (bottom) roller wheel D through a double intermediate B/C. The wheels A and B are connected by a chain. The pinion E on the drawing roller shaft, drives the retaining (top) roller wheel K through two double intermediates F/G and H/J. The pinion L



Sliver Spinning Frame (Mackie) Gearing—Gearing side

on the retaining roller shaft, drives the slip draft roller wheel M.

On the pulley side, the pinion L_1 on the retaining roller shaft, drives the heart cam wheel P through the double intermediate N/O. A bowl acting on the heart cam is attached to a lever. One end of the lever is fixed to the framework of the machine. The other end of the lever

is connected to the semi-circular traverse plate through connecting rod and chain. A number of wheels on the traverse plate shaft are attached to the bobbin board rail by means of chains. The up and down motion of the lever causes the traverse plate to revolve forward and backward. This movement of the traverse plate shaft causes the bobbin board rail to travel up and down. The traverse may be manipulated by means of the traverse hand wheel through a train of gearing consisting of the hand wheel pinion, one double intermediate and the traverse wheel. When the spinning frame is on, the double intermediate is kept out of gear. The hand wheel is used for doffing when the machine is off.

The operation of doffing is done by the forward and backward movement of the bobbin board holder. The sliding movement of the bobbin board holder is obtained by rack and pinion arrangement. When the bobbins are full, the machine is stopped. The empty bobbin board is at that time at the back position. The double intermediate in the traverse hand wheel gearing is put in gear by means of a clutch and the full bobbin board is lowered down on the sliding bobbin board holder. The full bobbin board presses a lock which keeps the empty bobbin board in position. By moving the bobbin changing hand wheel the bobbin board holder is slided forward. The empty bobbin board comes in position of the full bobbin board and the full bobbin board comes in the forward position. The empty bobbin board is then lifted up and the machine is made to run for a few seconds. After this the yarn is cut off from the full bobbins with the doffing knife and the machine is started. The full bobbins are replaced by

empty ones. The bobbin board holder is slided and locked in the back position.

Motor speed	...	A_1	r. p. m.
Diameter of motor pulley	...	b	inches
Diameter of cylinder pulley	...	c	,,
Diameter of cylinder	...	d	,,
Diameter of flyer wharve	...	e	,,
Diameter of drawing roller	...	f	,,
Diameter of retaining roller	...	g	,,

Flyer speed :

$$A_1 \times \frac{b}{c} \times \frac{d}{e} \text{ r. p. m.}$$

Drawing roller speed :

$$A_1 \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \text{ r. p. m.}$$

$$A_1 \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{f \times 3{\cdot}14}{12} \text{ f. p. m.}$$

Retaining roller speed :

$$A_1 \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{G}{H} \times \frac{J}{K} \text{ r. p. m.}$$

$$A_1 \times \frac{b}{c} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{G}{H} \times \frac{J}{K} \times \frac{g \times 3{\cdot}4}{12} \text{ f. p. m.}$$

To allow for the fluting of the roller, retaining roller circumference is taken as diameter $\times$ 3·4 in case of $4\frac{1}{4}''$ pitch frames and diameter $\times$ 3·5 in case of $5\frac{1}{2}''$ pitch frames.

Draft constant :

$$\frac{f \times 3{\cdot}14}{E} \times \frac{F}{G} \times \frac{H}{1} \times \frac{K}{g \times 3{\cdot}4} = k$$

$$\text{Draft} = \frac{\text{Draft constant}}{\text{Change pinion}} = \frac{k}{J}$$

Twist constant :

$$\frac{D}{1} \times \frac{B}{A} \times \frac{d}{e} \times \frac{1}{f \times 3{\cdot}14} = l$$

$$\text{Twist} = \frac{\text{Twist constant}}{\text{Change pinion}} = \frac{l}{C}$$

Example

Motor speed	...	1465	r. p. m.
Diameter of motor pulley	...	$9\frac{15}{16}$	inches
Diameter of cylinder pulley	...	$10\frac{9}{16}$	,,
Diameter of cylinder	...	$5\frac{7}{8}$	,,
Diameter of flyer wharve	...	2	,,
Cylinder pinion	...	19	teeth
Double intermediate	...	58/36	,,
Drawing roller wheel	...	120	,,
Diameter of drawing roller	...	$2\frac{1}{4}$	inches
Pinion on drawing roller shaft	...	24	teeth
Double intermediate	...	50/33	,,
Double intermediate	...	100/40	,,
Retaining roller wheel	...	100	,,
Diameter of retaining roller	...	$2\frac{1}{2}$	inches

Flyer speed :

$$1465 \times \frac{9\frac{15}{16}}{10\frac{9}{16}} \times \frac{5\frac{7}{8}}{2} = 4048{\cdot}8 \text{ r. p. m.}$$

Drawing roller speed :

$$1465 \times \frac{9\frac{15}{16}}{10\frac{9}{16}} \times \frac{19}{58} \times \frac{36}{120} = 135{\cdot}45 \text{ r. p. m.}$$

$$135{\cdot}45 \times \frac{2{\cdot}25 \times 3{\cdot}14}{12} = 79{\cdot}75 \text{ f. p. m.}$$

Retaining roller speed :

$$1465 \times \frac{9\frac{15}{16}}{10\frac{9}{16}} \times \frac{19}{58} \times \frac{36}{120} \times \frac{24}{50} \times \frac{33}{100} \times \frac{40}{100}$$

$$= 8{\cdot}58 \text{ r. p. m.}$$

$$8{\cdot}58 \times \frac{2{\cdot}5 \times 3{\cdot}4}{12} = 6{\cdot}08 \text{ f. p. m.}$$

$$\text{Draft constant } = \frac{2{\cdot}25 \times 3{\cdot}14}{24} \times \frac{50}{33} \times \frac{100}{1} \times \frac{100}{2{\cdot}5 \times 3{\cdot}4} = 525$$

$$\text{Draft } = \frac{525}{40} = 13{\cdot}12$$

$$\text{Twist constant } = \frac{120}{1} \times \frac{58}{19} \times \frac{5\frac{7}{8}}{2} \times \frac{1}{2{\cdot}25 \times 3{\cdot}14} = 152$$

$$\text{Twist } = \frac{152}{36} = 4{\cdot}22$$

Draft and Twist

$$\text{Draft } = \frac{\text{Rove or sliver weight per spyndle}}{\text{Yarn weight per spyndle}} \times \frac{100}{96}$$

$\frac{100}{96}$ is the allowance for the contraction in length due to twist.

$$\text{Twist } = \frac{K}{\sqrt{\text{Yarn weight per spyndle}}}$$

To find the required turns per inch for any yarn the following values of K may be taken :

Hessian warp	...	11 to 12
Hessian weft	...	10 to 11
Sacking warp	...	12 to 13
Sacking weft	...	12 to 13.

Some Points on Spinning Calculations

(i) Flyer revs.—Bobbin revs. = Winding-on revs.

(ii) Winding-on revs. = $\dfrac{\text{Delivery}}{\text{Circumference of bobbin}}$

(iii) Turns per inch = $\dfrac{\text{Spindle revs.}}{\text{Delivery in inches}}$

Changing Sizes

(i) From the same rove or sliver with same degree of twist :—

Yarn weight per spyndle to be changed from W lbs. to W_1 lbs., W_1 being greater than W.

Draft pinion for W lbs. yarn ... a teeth
Twist pinion ,, ,, ,, ... b ,,

Draft pinion for W_1 lbs. yarn :

Heavier yarn—Less draft—Bigger draft pinion

$a \times \dfrac{W_1}{W}$ teeth.

Twist pinion for W_1 lb. yarn :

Heavier yarn—Less turns per inch—Bigger twist pinion

$b \times \dfrac{\sqrt{W_1}}{\sqrt{W}}$ teeth.

Example

Draft pinion for 8 lbs. yarn ... 30 teeth
Twist pinion ,, ,, ,, ... 44 ,,

Yarn weight to be changed to 10 lbs. with the same degree of twist.

Draft pinion for 10 lbs. yarn $= 30 \times \frac{10}{8} = 37{\cdot}5$ i.e., 38 teeth

Twist pinion ,, ,, ,, $= 44 \times \frac{\sqrt{10}}{\sqrt{8}} = 49{\cdot}5$ i.e., 50 ,,

(ii) From different roves or slivers and to have different turns per inch :—

Yarn weight per spyndle to be changed from W lbs. to W_1 lbs., W_1 being greater than W.

W lbs. yarn (hessian warp) with e turns per inch and from x lbs. rove or sliver per spyndle.

W_1 lbs. yarn (hessian weft) with f turns per inch and from y lbs. rove or sliver per spyndle.

Draft pinion for W lbs. yarn ... a teeth

Twist pinion ,, ,, ,, ... b ,,

Draft pinion for W_1 lbs. yarn :

Draft in case of W lbs. yarn $= \frac{x}{W} = d$

Draft in case of W_1 lbs. yarn $= \frac{y}{W_1} = d_1$

d is greater than d_1.

Less draft—Bigger draft pinion

$$a \times \frac{d}{d_1} \text{ teeth.}$$

Twist pinion for W_1 lbs. yarn :

e is greater than f.

Less twist—Bigger twist pinion

$$b \times \frac{e}{f} \text{ teeth.}$$

Example

8 lbs. hessian warp yarn to be changed to 10 lbs. hessian weft yarn. The rove weight for hessian warp and

hessian weft are 72 lbs. and 80 lbs. respectively. Draft pinion and twist pinion for 8 lbs. yarn are 30 teeth and 44 teeth respectively.

$$\text{Draft for 8 lbs. yarn} = \frac{72}{8} = 9$$

$$\text{Draft for 10 lbs. yarn} = \frac{80}{10} = 8$$

$$\text{Draft pinion for 10 lbs. yarn} = 30 \times \frac{9}{8} = 33{\cdot}75$$

i.e., 34 teeth

Turns per inch for 8 lbs. hessian warp yarn

$$= \frac{K}{\sqrt{8}} = \frac{12}{\sqrt{8}} = 4{\cdot}24$$

Turns per inch for 10 lbs. hessian weft yarn

$$= \frac{K}{\sqrt{10}} = \frac{11}{\sqrt{10}} = 3{\cdot}49$$

$$\text{Twist pinion for 10 lbs. yarn} = 44 \times \frac{4{\cdot}24}{3{\cdot}49}$$

$= 53{\cdot}45$ i.e., 53 teeth.

Spinning Frame—Production Calculations

Weight of yarn per 14400 yds.	...	W_6 lbs.
Surface speed of drawing roller	...	S_5 f. p. m.
Number of deliveries per frame	...	T_3

$$\text{Yarn per hour} = \frac{S_5 \times 60 \times T_3}{3} \text{ yds.}$$

$$\text{Weight of yarn per hour} = \frac{S_5 \times 60 \times T_3 \times W_6}{3 \times 14400} \text{ lbs.}$$

Production of spinning frame per day of x hours

$$= \frac{S_5 \times 60 \times T_3 \times W_6 \times x}{3 \times 14400} \text{ lbs.}$$

Example

Weight of yarn per spyndle	...	8 lbs.
Surface speed of drawing roller	...	62·28 f.p.m.
Number of deliveries per frame	...	72

Production of spinning frame per day of 10 hours

$$= \frac{62{\cdot}28 \times 60 \times 72 \times 8 \times 10}{3 \times 14400} = 498{\cdot}24 \text{ lbs.}$$

Spinning Efficiency

Spindle speed	...	S r. p. m.
Twist	...	T turns per inch
Number of spindles per frame	...	N
Number of spinning frames	...	N_1
Actual weight of yarn per spyndle		W lbs.
Actual production on the frames per week of 48 hours	...	W_1 lbs.

Inches per spindle per min. $= \dfrac{S}{T}$

Yds. per spindle per hour $= \dfrac{S \times 60}{T \times 36}$

Spyndles per spindle per week of 48 hours

$$= \frac{S \times 60 \times 48}{T \times 36 \times 14400}$$

Spyndles per frame per week $= \dfrac{S \times 60 \times 48 \times N}{T \times 36 \times 14400}$

Theoretical production on the frames in spyndles

$$= \frac{S \times 60 \times 48 \times N \times N_1}{T \times 36 \times 14400} = L$$

Actual production on the frames in spyndles

$$= \frac{W_1}{W} = L_1$$

$$\text{Efficiency} = \frac{L_1 \times 100}{L}\%.$$

The efficiency may also be calculated in the following way :

Theoretical production

$$= \frac{S \times 60 \times 48 \times N \times N_1 \times W}{T \times 36 \times 14400} = W_2 \text{ lbs.}$$

$$\text{Efficiency} = \frac{W_1 \times 100}{W_2}\%.$$

Example

Spindle speed	... 2800 r. p. m.
Twist	... 4 turns per inch
Number of spindles per frame	... 72
Number of spinning frames	... 30
Actual weight of yarn per spyndle	... 8·25 lbs.
Actual production on the frames per week of 48 hours	... 55440 lbs.

$$\text{Theoretical production} = \frac{2800 \times 60 \times 48 \times 72 \times 30}{4 \times 36 \times 14400}$$

$$= 8400 \text{ spyndles per week}$$

$$\text{Actual production} = \frac{55440}{8{\cdot}25} = 6720 \text{ spyndles per week}$$

$$\text{Efficiency} = \frac{6720 \times 100}{8400} = 80\%.$$

Moisture in yarn

The moisture content of yarn is very important. Excess moisture means presence of less fibre in the yarn. In this case the yarn will be lighter and deficient in strength. Less moisture in the yarn means an unnecessary

consumption of jute. The method of calculating equivalent counts of yarn at different regains is given below :

$$C_1 = \frac{C \times (100 + R_1)}{(100 + R)}$$

where, R = Actual regain % of the yarn
R_1 = Standard regain % of the yarn
C = Count of the yarn at actual regain %
C_1 = Equivalent count of the yarn at standard regain %.

Example

Actual count of hessian warp yarn at 12% regain ... 7·75 lbs.
Standard regain of the yarn ... 16 %
Equivalent count of the yarn at 16% regain

$$= \frac{7{\cdot}75 \times (100 + 16)}{(100 + 12)} = 8{\cdot}03 \text{ lbs.}$$

Problems

(i) Calculate the dollop weight to produce 9 lbs. hessian warp yarn on the following system :

Machine	Clock Length	Draft	Doubling
Breaker card	12 yds.	12	—
Finisher card	—	16	12 to 1
1st. drawing frame	—	4	4 to 1
2nd. drawing frame	—	6	2 to 1
Roving frame	—	8	—
Spinning frame	—	9	—

Allow 20% loss in weight due to evaporation of moisture and dropping.

$$\frac{\text{Dollop} \times 100}{12} \times \frac{1}{12} \times \frac{12}{16} \times \frac{4}{4} \times \frac{2}{6} \times \frac{1}{8} \times \frac{1}{9} \times \frac{144}{1} \times \frac{80}{100} = 9 \text{ lbs.}$$

$$\text{Dollop} = \frac{12 \times 12 \times 16 \times 4 \times 6 \times 8 \times 9 \times 100 \times 9}{100 \times 12 \times 4 \times 2 \times 144 \times 80} = 32{\cdot}40 \text{ lbs.}$$

(ii) The flyer speed of a spinning frame producing 9 lbs. hessian weft yarn, is 3400 r. p. m. Find the speed of the spinning bobbin when the diameter of the bobbin is 2 inches.

Turns per inch for 9 lbs. hessian weft yarn

$$= \frac{K}{\sqrt{9}} = \frac{11}{\sqrt{9}} = 3{\cdot}66$$

$$\text{Delivery} = \frac{3400}{3{\cdot}66} = 928{\cdot}96 \text{ inches per min.}$$

$$\text{Bobbin speed} = 3400 - \frac{928{\cdot}96}{2 \times 3{\cdot}14} = 3252{\cdot}08 \text{ r. p. m.}$$

(iii) The draft constant and twist constant of a spinning frame are 300 and 190 respectively. Calculate the draft and twist change pinions required to produce 8 lbs. hessian warp yarn from 72 lbs. rove. What would be the draft and twist change pinions if 80 lbs. rove be used to produce 10 lbs. hessian weft yarn ?

$$\text{Draft for 8 lbs. hessian warp yarn} = \frac{72}{8} = 9$$

$$\text{Draft pinion} = \frac{300}{9} = 33{\cdot}33 \text{ i.e., 33 teeth}$$

Turns per inch for 8 lbs. hessian warp yarn

$$= \frac{K}{\sqrt{8}} = \frac{12}{\sqrt{8}} = 4{\cdot}24$$

$$\text{Twist pinion} = \frac{190}{4{\cdot}24} = 47{\cdot}17 \text{ i.e., 47 teeth}$$

Draft for 10 lbs. hessian weft yarn $= \frac{80}{10} = 8$

Draft pinion $= 33 \times \frac{9}{8} = 37{\cdot}12$ i.e., 37 teeth

Turns per inch for 10 lbs. hessian weft yarn

$$= \frac{K}{\sqrt{10}} = \frac{11}{\sqrt{10}} = 3{\cdot}54$$

Twist pinion $= 47 \times \frac{4{\cdot}24}{3{\cdot}54} = 56{\cdot}29$ i.e., 56 teeth.

(iv) Roving frame :

Spindle speed 700 r. p. m., rove 72 lbs. per spyndle, twist on rove 0·70 turns per inch, efficiency 75%.

Spinning frame :

Spindle speed 3000 r. p. m., yarn 8 lbs. per spyndle, twist on yarn 4·25 turns per inch, efficiency 80%.

From the above data, calculate the number of spinning spindles per roving spindle.

Delivery per min. per roving spindle

$$= \frac{700}{0{\cdot}70} \times \frac{72}{36 \times 14400} \times \frac{75}{100} = 0{\cdot}104 \text{ lbs.}$$

Delivery per min. per spinning spindle

$$= \frac{3000}{4{\cdot}25} \times \frac{8}{36 \times 14400} \times \frac{80}{100} = 0{\cdot}009 \text{ lbs.}$$

No. of spinning spindles per roving spindle

$$= \frac{0{\cdot}104}{0{\cdot}009} = 11{\cdot}55.$$

(v) In a spinning flat, 16 spinning frames are producing hessian warp yarn. Each spinning frame has 100 spindles. The spindles are running at 4000 r. p. m. Actual

weight of the yarn is 8·10 lbs. per spyndle. Twist on the yarn is 4·25 turns per inch. Total production of hessian warp yarn in 10 hours is 12000 lbs. Find the spinning efficiency.

Theoretical production

$$=\frac{4000 \times 60 \times 10 \times 100 \times 16 \times 8{\cdot}1}{4{\cdot}25 \times 36 \times 14400}=14117 \text{ lbs.}$$

$$\text{Efficiency} = \frac{12000 \times 100}{14117}=85\%.$$

(vi) Calculate the dollop weight to produce 8 lbs. hessian warp yarn and the requirement of preparing machinery to feed 16 sliver spinning frames from the following details :

Breaker card— clock length 13·1 yds., draft 12·5, drawing roller speed 77 yds. per min., efficiency 80%, loss 7%.

Finisher card— doubling 10 to 1, draft 15, drawing roller speed 85·5 yds. per min., efficiency 80%, loss 3·5%.

1st. drawing frame—doubling 4 to 1, draft 5·5, deliveries per machine 4, drawing roller speed 31·79 yds. per min., efficiency 70%, loss 2·5%.

2nd. drawing frame—doubling 2 to 1, draft 5·5, deliveries per machine 4, drawing roller speed 44·26 yds. per min., efficiency 70%, loss 2·5%.

3rd. drawing frame—doubling 2 to 1, draft 9, deliveries per machine 20, drawing roller speed 51·4 yds. per min., efficiency 75%, loss 2·5%.

Spinning frame— draft 11, deliveries per machine 100, spindle speed 4000 r. p. m., twist 4·25 turns per inch, efficiency 90%, loss 2%.

$$\frac{\text{Dollop} \times 14400}{13{\cdot}1} \times \frac{1}{12{\cdot}5} \times \frac{10}{15} \times \frac{4}{5{\cdot}5} \times \frac{2}{5{\cdot}5} \times \frac{2}{9} \times \frac{1}{11} = 8 \text{ lbs.}$$

$$\text{Dollop} = \frac{13{\cdot}1 \times 12{\cdot}5 \times 15 \times 5{\cdot}5 \times 5{\cdot}5 \times 9 \times 11 \times 8}{14400 \times 10 \times 4 \times 2 \times 2}$$

$$= 25{\cdot}54 \text{ lbs.}$$

Allowing 20% loss from breaker card to spinning frame,

$$\text{Dollop} = 25{\cdot}54 \times \frac{120}{100} = 30{\cdot}65 \text{ lbs.}$$

16 spinning frames $= 16 \times 100 = 1600$ spindles

Spinning production per hour at 90% efficiency

$$= \frac{4000}{4{\cdot}25} \times \frac{1}{36} \times \frac{1}{14400} \times \frac{60}{1} \times \frac{8}{1} \times \frac{1600}{1} \times \frac{90}{100} = 1255 \text{ lbs.}$$

3rd. drawing frame delivery allowing 2% loss in spinning frame

$$= 8 \times 11 \times \frac{102}{100} = 89{\cdot}76 \text{ lbs. per 14400 yds.}$$

$$= 89{\cdot}76 \times \frac{1000}{14400} = 6{\cdot}23 \text{ lbs. per 1000 yds.}$$

Production per 3rd. drawing frame delivery

$= 51{\cdot}4 \times 60 = 3084$ yds. per hour

Production per 3rd. drawing frame (20 dels.)

$= 3084 \times 20 = 61680$ yds. per hour

$$= \frac{61680 \times 6{\cdot}23}{1000} = 384{\cdot}26 \text{ lbs. per hour}$$

Should be production of 3rd. drawing frame allowing 2% loss in spinning

$$= 1255 \times \frac{102}{100} = 1280 \text{ lbs. per hour}$$

No. of 3rd. drawing frames required at 75% efficiency

$$= \frac{1280}{384{\cdot}26} \times \frac{100}{75} = 4{\cdot}44$$

2nd. drawing frame delivery allowing 2·5% loss in 3rd. drawing frame

$$= 6{\cdot}23 \times \frac{9}{2} \times \frac{102{\cdot}5}{100} = 28{\cdot}73 \text{ lbs. per 1000 yds.}$$

Production per 2nd. drawing frame delivery

$$= 44{\cdot}26 \times 60 = 2655{\cdot}6 \text{ yds. per hour}$$

Production per 2nd. drawing frame (4 dels.)

$$= 2655{\cdot}6 \times 4 = 10622{\cdot}4 \text{ yds. per hour}$$

$$= \frac{10622{\cdot}4 \times 28{\cdot}73}{1000} = 305{\cdot}18 \text{ lbs. per hour}$$

Should be production of 2nd. drawing frame allowing 2·5% loss in 3rd. drawing frame

$$= 1280 \times \frac{102{\cdot}5}{100} = 1312 \text{ lbs. per hour}$$

No. of 2nd. drawing frames required at 70% efficiency

$$= \frac{1312}{305{\cdot}18} \times \frac{100}{70} = 6{\cdot}14$$

1st. drawing frame delivery allowing 2·5% loss in 2nd. drawing frame

$$= 28{\cdot}73 \times \frac{5{\cdot}5}{2} \times \frac{102{\cdot}5}{100} = 80{\cdot}98 \text{ lbs. per 1000 yds.}$$

Production per 1st. drawing frame delivery

$$= 31{\cdot}79 \times 60 = 1907{\cdot}4 \text{ yds. per hour}$$

Production per 1st. drawing frame (4 dels.)

$$=1907{\cdot}4\times4=7629{\cdot}6 \text{ yds. per hour}$$

$$=\frac{7629{\cdot}6\times80{\cdot}98}{1000}=617{\cdot}85 \text{ lbs. per hour}$$

Should be production of 1st. drawing frame allowing 2·5% loss in 2nd. drawing frame

$$=1312\times\frac{102{\cdot}5}{100}=1345 \text{ lbs. per hour.}$$

No. of 1st. drawing frames required at 70% efficiency

$$=\frac{1345}{617{\cdot}85}\times\frac{100}{70}=3{\cdot}1$$

Finisher card delivery allowing 2·5% loss in 1st. drawing frame

$$=80{\cdot}98\times\frac{5{\cdot}5}{4}\times\frac{102{\cdot}5}{100}=114{\cdot}13 \text{ lbs. per 1000 yds.}$$

Production per finisher card

$$=85{\cdot}5\times60=5130 \text{ yds. per hour}$$

$$=\frac{5130\times114{\cdot}13}{1000}=585{\cdot}48 \text{ lbs. per hour}$$

Should be production of finisher card allowing 2·5% loss in 1st. drawing frame

$$=1345\times\frac{102{\cdot}5}{100}=1379 \text{ lbs. per hour}$$

No. of finisher cards required at 80% efficiency

$$=\frac{1379}{585{\cdot}48}\times\frac{100}{80}=2{\cdot}94$$

Breaker card delivery allowing 3·5% loss in finisher card

$$=114{\cdot}13\times\frac{15}{10}\times\frac{103{\cdot}5}{100}=177{\cdot}18 \text{ lbs. per 1000 yds.}$$

Production per breaker card

$$= 77 \times 60 = 4620 \text{ yds. per hour}$$

$$= \frac{4620 \times 177 \cdot 18}{1000} = 818 \cdot 57 \text{ lbs. per hour}$$

Should be production of breaker card allowing 3·5% loss in finisher card

$$= 1379 \times \frac{103 \cdot 5}{100} = 1427 \text{ lbs. per hour}$$

No. of breaker cards required at 80% efficiency

$$= \frac{1427}{818 \cdot 57} \times \frac{100}{80} = 2 \cdot 18.$$

CHAPTER XI

REELING AND TWISTING

Reeling

For bleaching and dyeing the yarn from the spinning bobbin is wound on the circumference of a reel into hanks of a definite continuous length. This process is known as reeling. The spinning bobbins are placed on the spindles fixed on the bobbin board at the top of the reeling machine which mainly consists of a long horizontal frame called a swift. The rotation of the swift causes the yarn to be wound on the circumference of the swift. The circumference is usually 2·5 yards. One thread guide in front of every bobbin helps even winding. Each successive 120 threads are kept separate by leasing. 120 revolutions of the swift provide a cut. The ends may not be traced at once during reeling when the ends break or the bobbins run out. To allow for this 124 revolutions are made instead of 120. The reeling of each 124 threads is indicated by the ringing of a bell worked from the swift through a screw and worm wheel. The swift is made collapsible so that the hanks of yarn may be taken off it. The deficiency in the number of threads in a hank is known as "short tell" and this fault in reeling should not exceed reasonable limits.

Yarn Table

The count of jute yarn is usually expressed by the fixed length system. The fixed length is 14400 yards known as

a spyndle. The count may also be expressed by the fixed weight system, the fixed weight being 1 pound.

The Jute Count (Fixed Length System)

One circumference of the reel	= 1 thread	= $2\frac{1}{2}$ yds.
120 threads	= 1 cut	= 300 ,,
2 cuts	= 1 heer	= 600 ,,
12 cuts	= 1 standard hank	= 3600 ,,
4 hanks	= 1 spyndle	= 14400 ,,

The Lea Count (Fixed Weight System)

One circumference of the reel	= 1 thread	= $2\frac{1}{2}$ yds.
120 threads	= 1 lea or cut	= 300 ,,
200 cuts	= 1 bundle	= 60000 ,,

In the fixed length system, the count is the weight of 14400 yds. of yarn in pounds. Thus, a 9 lb. yarn means that 14400 yds. of the yarn weigh 9 pounds. In this system, the heavier the yarn, the higher the count.

In the fixed weight system, the count is the number of leas to weigh 1 pound. Thus, a 20 lea yarn or 20's yarn means that 20 leas of the yarn weigh 1 pound. In this system, the heavier the yarn, the lower the count.

W lb. ... Weight of 1 spyndle i.e., 48 cuts

1 lb. ... Weight of $\frac{48}{W}$ cuts

$$\text{Lea Count} = \frac{48}{W} = \frac{48}{\text{Jute Count}}$$

$$\text{Lea Count} \times \text{Jute Count} = 48.$$

For cotton yarn the reeling length or unit is a hank of 840 yards. The count of the yarn is determined by the number of hanks per pound. Thus, when 12 hanks of cotton yarn weigh 1 lb. the count of the yarn is 12's.

Yarn Test for Grist

The yarn from 6 spinning bobbins are wound on the circumference of a reel for 60 rotations of the reel. The circumference of the reel is $2\frac{1}{2}$ yards. The length of yarn on the reel is $6 \times 60 \times 2\frac{1}{2} = 900$ yards. The weight of the yarn in ounces expressed in pounds is the count of the yarn. Thus, if the weight of the yarn is 9 ounces, the yarn weight per spyndle should be 9 lbs.

Twisting

Twisting is the process of making multiply yarn. The single yarns are twisted in the direction opposite to the direction of twist in the single yarns.

In the twisting frame, the bobbins are placed on the creel. The single yarns pass through the guide, over the top roller, between the top roller and the bottom roller and finally on to the flyer and bobbin.

If 'A' lb. yarn, 'B' lb. yarn and 'C' lb. yarn are twisted together, the resultant count of the compound yarn will be $(A + B + C)$ lb., neglecting the shrinkage in length during the operation of twisting. Thus, if 8 lb. per spyndle yarn, 9 lb. per spyndle yarn and 10 lb. per spyndle yarn are twisted together, the count of the resultant yarn would be $8 + 9 + 10 = 27$ lbs. per spyndle. Similarly if 5 threads of 6 lbs. per spyndle yarn are twisted together the resultant

count of the compound yarn would be $5 \times 6 = 30$ lbs. per spyndle usually known as 5/6's or 5-ply 6's.

When a number of twisted yarns are again twisted together the process is called 'Cabling'. The direction of twist in the cabled yarn is opposite to that of the component twisted yarns.

Problems

(i) Calculate pounds per spyndle of a yarn measuring 450 yds. and weighing 4 ozs. and also the equivalent lea number.

450 yds. weigh 4 ozs.

14400 yds. weigh $\frac{4 \times 14400}{450 \times 16} = 8$ lbs.

Lea count $= \frac{48}{8} = 6$'s.

(ii) If a 56 lb. bundle of jute yarn contains 5 spyndles and 24 cuts, what is the count of the yarn ?

5 spyndles and 24 cuts $= 5{\cdot}5$ spyndles

Count of the yarn $= 56 \div 5{\cdot}5 = 10{\cdot}18$ lbs. per spyndle.

(iii) A 56 lb. bundle of (supposed) 8 lb. jute warp yarn is found to be reeled 2% short in length. How many yards of yarn does it actually contain ?

$56 \div 8 = 7$ spyndles

$7 \times 14400 \times \frac{98}{100} = 98784$ yds.

(iv) If the weight of a bundle of 8 lb. yarn was 2 pounds heavier than it should be and there were 12 threads short of the proper number in every hank, what would be the weight of the yarn per spyndle ? Give the percentage heavy or light.

The average weight of a bundle of yarn is 56 pounds.

Weight of the bundle $=56+2=58$ lbs.

$1440-12=1428$ threads per hank

$$8\times\frac{58}{56}\times\frac{1440}{1428}=8{\cdot}36 \text{ lbs. per spyndle}$$

$$\frac{(8{\cdot}36-8)\times 100}{8}=4{\cdot}5\% \text{ heavy.}$$

(v) A bundle of 7 lbs. jute yarn which should contain 8 spyndles, weighs 56 lbs. It is found that each cut is 10 threads short and that each thread is 91 inches long. Find the actual grist of the yarn.

The apparent weight of the yarn $=\frac{56}{8}=7$ lbs. per spyndle

Each hank has $1440-10=1430$ threads instead of 1440 threads.

Each thread is 91 inches long instead of 90 inches.

Actual grist of the yarn $=7\times\frac{1440}{1430}\times\frac{90}{91}=6{\cdot}97$ lbs. per spyndle.

(vi) If the weight of a bundle of 8 lb. yarn was 2% lighter than it should be and that each thread is $89\frac{1}{2}$ inches long, what would be the weight per spyndle of the yarn ?

$$8\times\frac{98}{100}\times\frac{90}{89{\cdot}5}=8{\cdot}19 \text{ lbs. per spyndle.}$$

(vii) 26880 yds. of cotton yarn weigh 2 lbs. What is the count of the cotton yarn ? What is the equivalent jute count ?

2 lbs. is the weight of 26880 yds. of yarn.

1 lb. „ „ „ „ $\frac{26880}{2}=13440$ yds. of yarn.

$$13440 \text{ yds.} = \frac{13440}{840} = 16 \text{ hanks}$$

Hence count of the cotton yarn = 16's.

13440 yds. of cotton yarn weigh 1 lb.

1 yd. ,, ,, ,, weighs $\frac{1}{13440}$ lb.

14400 yds. ,, ,, ,, weigh $\frac{14400}{13440} = 1{\cdot}07$ lb.

Equivalent jute count = 1·07 lbs. per spyndle.

(viii) Convert 10 lbs. jute yarn to equivalent cotton count.

10 lbs. is the weight of 14400 yds. of jute yarn.

1 lb. ,, ,, ,, ,, $\frac{14400}{10} = 1440$ yds. of jute yarn.

$$1440 \text{ yds.} = \frac{1440}{840} = 1{\cdot}714 \text{ hanks}$$

Hence equivalent cotton count of the jute yarn = 1·714's.

CHAPTER XII

WINDING AND BEAMING

Warp and Weft

There are two types of yarn—warp and weft. The warp yarn from the spinning bobbins, is usually made into spools. These are also known as rolls or cheeses. Generally wooden tubes form the base of the spools. The spools are made in the spool winding machine. Bobbin winding is employed for dyed and bleached yarns. Warping mills are sometimes used also.

The weft yarn is usually made into cops in a cop winding machine. Pirn winding is also occasionally adopted. In this case, the weft yarn is wound on to wooden pirns.

Warp Winding

A uniform speed of yarn, a quick traverse and an automatic method of breaking the connection between the spool and the spool driver when the spool reaches the required diameter, are the essential requirements of a spool winding machine.

The spool drivers are the main parts of a spool winding machine. The four main shafts carry the spool drivers which are placed at regular distances along the shafts. The yarn is wound on wooden spool centres which revolve on iron spindles through surface contact with the spool drivers. The uniform speed of the spool drivers ensures the uniform speed of the yarn. Each spindle is carried by two arms of a bracket which is fulcrumed behind the

spool so that the bracket with the spool centre rises as the spool fills. When the spool reaches the required diameter, it becomes clear of the spool driver and the spool is automatically stopped.

The yarn from the spinning bobbin, passes over the angular or barrel-shaped breast plate and thence through the respective thread guide on to the spool. The thread guides, one for each spool, are attached to a traverse rod which receives a quick to-and-fro motion by means of some form of cam or split pulley.

One end of a suitably shaped flat lever with an internal spring on its fulcrum, is in constant contact with the yarn on the spinning bobbin to impart the necessary drag on the bobbin. As the bobbin empties the force of the spring decreases.

In a spool winding machine (Combe Barbour) the pulleys are driven from the drum on the driving shaft through belting. The pulley shaft serves as one of the bottom shafts of the machine. The pinion on the other end of the shaft drives the top main shaft wheel on the same side through a single intermediate and the two main shaft wheels on the other side through two single intermediates. The tappet driving wheel on the pulley shaft, drives the tappet wheels through a double intermediate (friction). Two top traverse rods are driven by the top tappet and two bottom traverse rods are driven by the bottom tappet.

Driving shaft speed	...	R	r. p. m.
Diameter of drum	...	d	inches
Diameter of pulley	...	p	,,
Pinion on the other end of the pulley shaft		A	teeth

Main shaft wheels ... B teeth

Diameter of spool driver ... d_1 inches

Pulley shaft speed $= R \times \dfrac{d}{p}$ r. p. m.

Spool driver speed

$$= R \times \frac{d}{p} \times \frac{A}{B} \times \frac{d_1 \times 3{\cdot}14}{36} \text{ yds. per min.}$$

Example

Driving shaft speed ...	168 r.p.m.
Diameter of drum ...	44 inches
Diameter of pulley ...	18 „
Pinion on the other end of the pulley shaft	88 teeth
Main shaft wheels ...	88 „
Diameter of spool driver ...	$4\frac{1}{8}$ inches

Pulley speed $= 168 \times \dfrac{44}{18} = 410{\cdot}66$ r. p. m.

Spool driver speed

$$= 168 \times \frac{44}{18} \times \frac{88}{88} \times \frac{4\frac{1}{8} \times 3{\cdot}14}{36} = 147{\cdot}67 \text{ yds. per min.}$$

Weft Winding

In cop winding the yarn is wound in a conical form on a bare spindle which is withdrawn when winding is completed. The cross method of winding obtained by the quick traverse of the guide finger ensures the stable nature of the cop. In some cop winding machines the tapered end of the cop points upwards and in others points downwards.

In a cop winding machine (Fairbairn, Lawson, Combe Barbour) the pulleys on the main shaft, are driven from the drum on the driving shaft through belting. The main

shaft carries a number of bevel wheels. Each bevel wheel is in gear with a bevel pinion which runs loosely on a vertical spindle. When the bevel pinion and a clutch on the spindle are in contact, the spindle rotates and draws weft yarn from the spinning bobbin. A suitably shaped lever with an internal spring on its fulcrum, imparts the necessary brake on the bobbin. The yarn from the bobbin passes over a porcelain thread guide, thence through the guide finger and finally through a slot of the cone to the spindle. The upward and downward movement of the guide finger attached to the rocking shaft, imparts the necessary traverse to the yarn. The rocking shaft receives its motion from the main shaft through the eccentric driving wheel on the main shaft, eccentric wheel, eccentric rod and an arm. When the yarn breaks or the bobbin is exhausted or the cop reaches the required length, the bevel pinion and the clutch are out of contact by suitable lever arrangement and the spindle is stopped automatically. As the cop fills, the spindle and the footstep which is attached to the lower end of the spindle, come down. The footstep is connected to a heavy weight by means of a chain and slides up and down along a bracket. When the cop is full, the footstep is pushed down to withdraw the spindle from the cop.

Driving shaft speed	...	R r. p. m.
Diameter of drum	...	d inches
Diameter of pulley	...	p ,,
Main shaft bevel wheel	...	A teeth
Spindle bevel pinion	...	B ,,

$$\text{Spindle speed} = R \times \frac{d}{p} \times \frac{A}{B} \text{ r. p. m.}$$

Example

Driving shaft speed	...	168 r.p.m.
Diameter of drum	...	42 inches
Diameter of pulley	...	13 ,,
Main shaft bevel wheel	...	44 teeth
Spindle bevel pinion	..	24 ,,

$$\text{Spindle speed} = 168 \times \frac{42}{13} \times \frac{44}{24} = 995{\cdot}07 \text{ r. p. m.}$$

Dressing and Beaming

The operations of sizing, drying and beaming of jute warp yarns are carried on simultaneously by a dressing machine.

Sizing lays the loose fibres on the surface of the yarn, so making it work better in the loom. It also improves the finish of the fabric. A sizing mixture mainly consists of an adhesive substance e.g., wheaten flour, farina, maize flour, tamarind seed powder etc. The mixture may have one or more of the following auxiliaries :

(i) Deliquescents e.g., magnesium chloride, calcium chloride etc.,

(ii) Softeners e.g., tallow, wax, oils etc.,

(iii) Gelatinisers e.g., caustic soda, soda ash etc.,

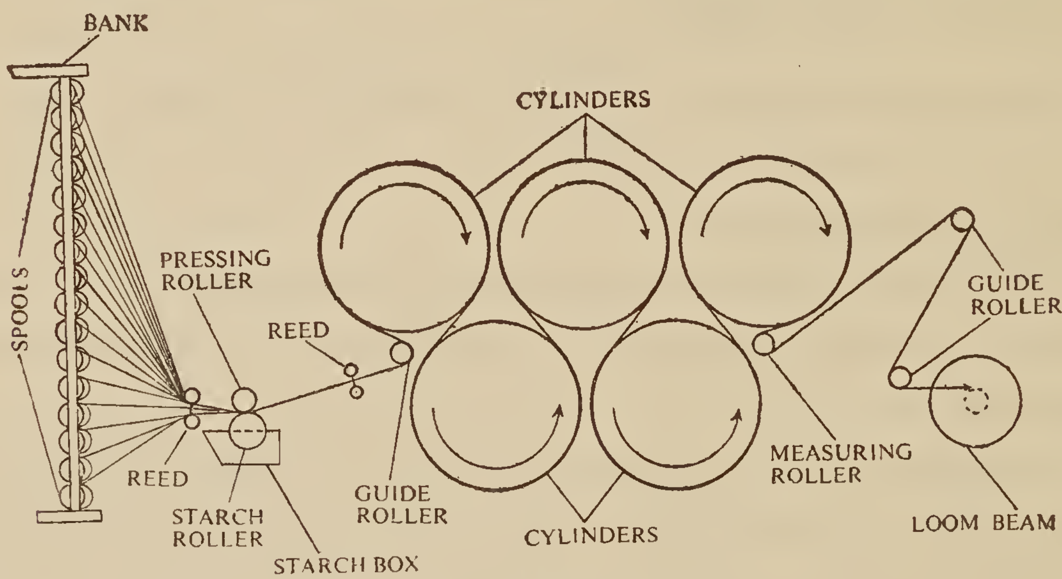
(iv) Weighting agents e.g., china clay, talc etc.,

(v) Antiseptics e.g., zinc chloride, salicylic acid, shirlan A. G., shirlan N. A. etc.

An usual dressing mixture may contain 80 lbs. tamarind seed powder, 2 lbs. salicylic acid and 1 lb. soda ash and the volume is made upto 400 gallons with water.

The yarns from the spools in the bank, pass through a reed in pairs, then between the starch roller and the

pressing roller. The starch roller is partially immersed in the sizing mixture contained in the starch box and the pressing roller is pressed to the starch roller by levers and weights. The starched yarns from the starching rollers, pass through a guide reed, round a guide roller and then



Dressing Machine

are dried on the steamheated drying cylinders. The dried yarns pass behind a measuring roller, round two guide rollers and finally on to the loom beam. The yarn on the beam is firmly pressed by the dead weight of the pressing rollers and the massive framework carrying these. A rack and pinion arrangement may raise the pressing rollers and the framework clear of the beam.

In a dressing machine (Robertson, Orchar) the pulleys are driven from the drum on the driving shaft. The pulley shaft pinion (speed change) drives the main shaft wheel through a single intermediate. The bevel pinion on the main shaft drives the side shaft bevel wheel. The bevel pinion on the side shaft drives the cross shaft bevel wheel. The pinion on the cross shaft drives the starch roller wheel

through a double intermediate. The yarn is drawn from the spools by the starch roller and the pressing roller. The speed of the starch roller and therefore the speed of the yarn is constant. If the speed of the beam be constant, its surface speed increases as the beam fills. So the beam is frictionally driven to keep the yarn in tension as it is wound on the beam. Two friction plates with flannel discs mounted on a shaft which gives motion to the loom beam, may be brought into contact with the sides of the friction wheel. A hand wheel in conjunction with a spring regulates the pressure between the friction wheel and the friction plates. It is necessary to increase the friction as the beam fills. The friction wheel is positively driven from the main shaft. There are two pinions on the main shaft. These may be in gear with two corresponding wheels on a stud. When one set is in gear, the other would be out of gear. This change of gear is effected by a clutch fork. The stud pinion drives the friction wheel. A suitable gearing from the measuring roller puts the keel mark on the warp threads for every cut which goes on to the loom beam.

Driving shaft speed	...	R	r.p.m.
Diameter of drum	...	d	inches
Diameter of pulley	...	p	,,
Pulley shaft pinion	...	A	teeth
Main shaft wheel	...	B	,,
Bevel pinion on main shaft (to starch roller)	...	C	,,
Bevel wheel on side shaft	...	D	,,
Bevel pinion on side shaft	...	E	,,
Bevel wheel on cross shaft	...	F	,,

Pinion on cross shaft	...	G teeth
Double intermediate	...	H/J ,,
Starch roller wheel	...	K ,,
Diameter of starch roller	...	k inches
Pinions on main shaft (to loom beam)	...	L, M teeth
Stud wheels	...	L_1, M_1 ,,
Stud pinion	..	N ,,
Friction wheel	...	O ,,

Starch roller speed :

$$R \times \frac{d}{p} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{G}{H} \times \frac{J}{K} \text{ r. p. m.}$$

$$R \times \frac{d}{p} \times \frac{A}{B} \times \frac{C}{D} \times \frac{E}{F} \times \frac{G}{H} \times \frac{J}{K} \times \frac{k \times 3{\cdot}14}{36} \text{ yds. per min.}$$

Friction wheel speed :

$$R \times \frac{d}{p} \times \frac{A}{B} \times \frac{L}{L_1} \times \frac{N}{O} \text{ r. p. m. at the start of a beam.}$$

$$R \times \frac{d}{p} \times \frac{A}{B} \times \frac{M}{M_1} \times \frac{N}{O} \text{ r. p. m. at the end of a beam.}$$

Example

Driving shaft speed	...	150 r. p. m.
Diameter of drum	...	32 inches
Diameter of pulley	...	12 ,,
Pulley shaft pinion	...	42 teeth
Main shaft wheel	...	42 ,,
Bevel pinion on main shaft	...	25 ,,
Bevel wheel on side shaft	...	40 ,,
Bevel pinion on side shaft	...	20 ,,
Bevel wheel on cross shaft	...	40 ,,
Pinion on cross shaft	...	22 ,,
Double intermediate	...	72/29 ,,

Starch roller wheel	...	60 teeth
Diameter of starch roller	...	13 inches
Pinions on main shaft	...	30, 18 teeth
Stud wheels	...	56, 68 ,,
Stud pinion	...	14 ,,
Friction wheel	...	70 ,,
Diameter of empty beam	...	$5\frac{1}{2}$ inches

Starch roller speed :

$$150 \times \frac{32}{12} \times \frac{42}{42} \times \frac{25}{40} \times \frac{20}{40} \times \frac{22}{72} \times \frac{29}{60} \times \frac{13 \times 3{\cdot}14}{36}$$

$$= 20{\cdot}67 \text{ yds. per min.}$$

Empty beam speed :

$$150 \times \frac{32}{12} \times \frac{42}{42} \times \frac{30}{56} \times \frac{14}{70} \times \frac{5{\cdot}5 \times 3{\cdot}14}{36}$$

$$= 20{\cdot}60 \text{ yds. per min.}$$

Problems

(i) The weight of a spool is $7\frac{1}{2}$ lbs. If the actual weight of the yarn is $8\frac{1}{4}$ lbs., find the number of yards of yarn the spool contains.

$$\frac{14400 \times 7{\cdot}5}{8{\cdot}25} = 13090{\cdot}91 \text{ yds.}$$

(ii) A dressing machine bank is filled with warp spools. The weight of each spool is 7 lbs. and the warp is 9 lbs. per spyndle. How many cuts of 130 yds. each, can be run from the bank ?

$$\frac{14400 \times 7}{9 \times 130} = 86{\cdot}154 \text{ cuts.}$$

(iii) Find the production of a spool winding machine (72 spool drivers per side) for a day of 10 hours at 80%

efficiency winding 8 lbs. hessian warp. The spool drivers are 4 inches in diameter and run at 500 revs. per min.

Production per spool driver :

$$500 \times \frac{4 \times 3{\cdot}14}{36} = 174{\cdot}44 \text{ yds. per min.}$$

$$174{\cdot}44 \times 60 \times 10 = 104664 \text{ yds. per day of 10 hrs.}$$

$$\frac{104664}{14400} = 7{\cdot}27 \text{ spyndles per day of 10 hrs.}$$

$$7{\cdot}27 \times \frac{80}{100} = 5{\cdot}82 \text{ spyndles per day of 10 hrs. at } 80\% \text{ efficiency}$$

$$5{\cdot}82 \times 8 = 46{\cdot}56 \text{ lbs. per day of 10 hrs. at } 80\% \text{ efficiency}$$

Production per machine (2 sides) :

$$46{\cdot}56 \times 144 = 6704{\cdot}64 \text{ lbs. per day of 10 hrs. at } 80\% \text{ efficiency.}$$

(iv) The speed of a dressing machine is 20 yds. per min. The usual production of the machine is 7 beams per day of 10 hrs. Each beam contains 11 cuts of 130 yds. each. What is the efficiency of the dressing machine ?

Production of the dressing machine at 100% efficiency

$$= 20 \times 60 \times 10 = 12000 \text{ yds. per day of 10 hrs.}$$

Actual production $= 7 \times 11 \times 130 = 10010$ yds. per day of 10 hrs.

$$\text{Efficiency} = \frac{10010 \times 100}{12000} = 83{\cdot}42\%.$$

(v) If a beam contains 13 cuts of warp of 100 yds. each, intended for a fabric with 12 threads per inch and 40 in. wide, how many spyndles of warp does it contain ?

$$\frac{13 \times 100 \times 12 \times 40}{14400} = 43{\cdot}33 \text{ spyndles.}$$

(vi) A beam of starched warp contains 10 cuts of 130 yds. each. The beam has 484 warp threads and weighs 380 lbs. The weight of the warp yarn is 8 lbs. per spyndle. Find the percentage of starch applied on the yarn.

Spyndles of warp yarn on the beam

$$=\frac{484 \times 130 \times 10}{14400}=43{\cdot}69$$

Actual weight of the yarn on the beam

$$=43{\cdot}69 \times 8=349{\cdot}52 \text{ lbs.}$$

Weight of starch on the beam

$$=380-349{\cdot}52=30{\cdot}48 \text{ lbs.}$$

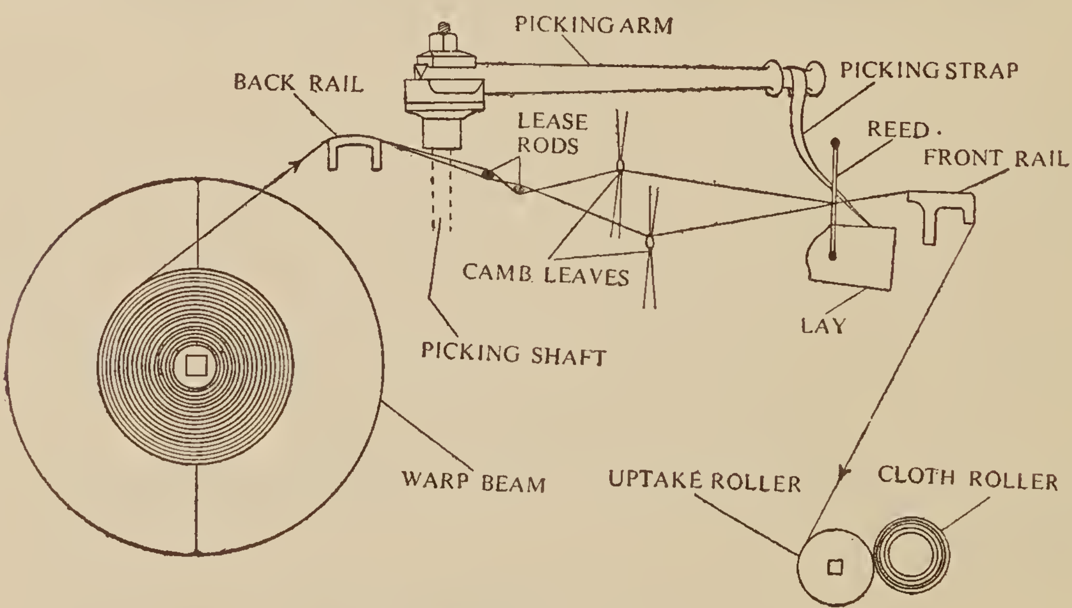
$$\text{Starch applied on the yarn}=\frac{30{\cdot}48 \times 100}{349{\cdot}52}=8{\cdot}72\%.$$

CHAPTER XIII

WEAVING

Drawing-in

The warp beam is placed at the back of the loom. The warp yarns pass over the back rail, through the mails of the camb leaves and then through the splits of the reed. For a plain fabric two leaves make a camb. Two warp threads are drawn through the mails of the leaves, one leaf for one thread, and then through the same split of



Drawing-in (Loom)

the reed. In a double warp plain fabric, four warp threads are drawn through the mails of the leaves, one leaf for two threads, and then through the same split of the reed. In case of a double warp, 3-leaf twill fabric, six warp threads are drawn through the mails of the three leaves,

one leaf for two threads, and then through the same split of the reed.

Camb and Reed

The leaves of the camb separate the warp threads into two layers for the passage of the shuttle with the weft.

The reed determines the fineness or coarseness of the fabric, serves as the back support of the shuttle during its passage and pushes forward the weft to the fell of the cloth.

Weaving

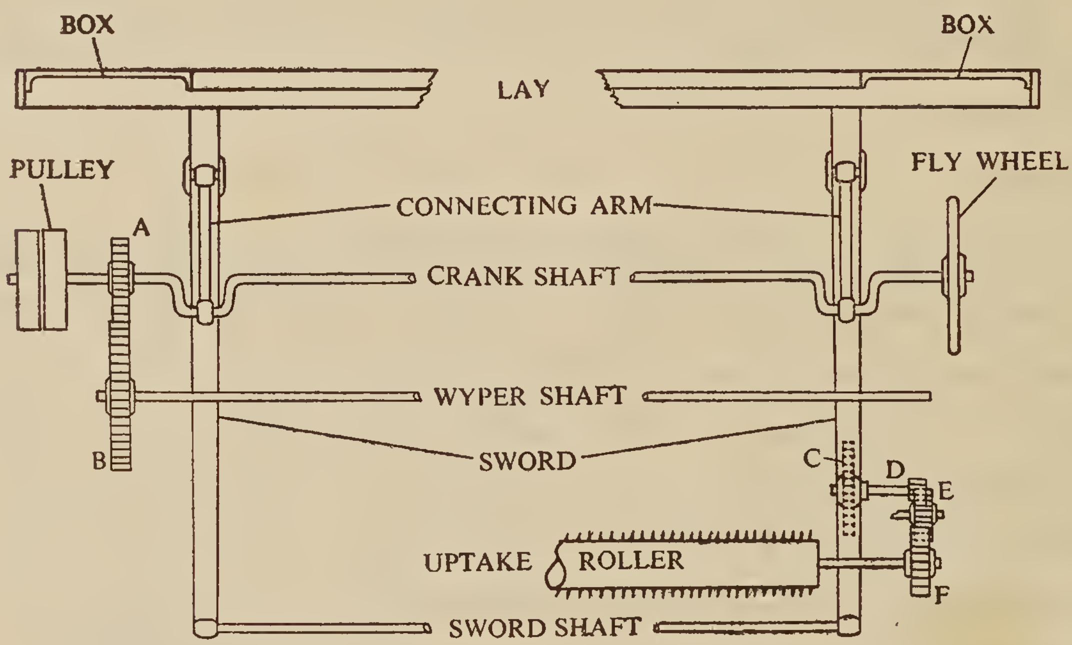
Weaving is the process of interlacing two distinct sets of yarns—warp and weft, to form a web of cloth. The operation of weaving is carried out in a loom. The warp yarns run lengthwise from end to end of the web and are supplied by the warp beam. The weft yarns cross and intersect the warp yarns at right angles. The shuttle fed by the cops, shoots the weft yarn to and fro between the warp yarns from selvedge to selvedge. The fine cloth is called 'Hessian' and the coarse cloth is called 'Sacking'.

The Loom

Shedding, picking and beating up are the three principal motions of a loom. Shedding is the separation of the warp threads for a passage of the shuttle with the weft. Picking is the operation of driving the shuttle from side to side of the loom. Beating up is the driving of the weft thread to the fell of the cloth by the reed. The loom has other motions also. Let-off motions control the rate at which the yarn is drawn from or released by the yarn

beam. Uptake motions control the rate at which the woven cloth passes round the periphery of the uptake roller. Warp protectors protect the warp threads by stopping the loom if the shuttle fails to clear the shed at the proper time.

In an ordinary plain loom (Robertson, Orchar) the wheel A on the crank shaft on one end of which the



Loom Gearing

driving pulleys are attached, drives the wyper shaft wheel B. On the wyper shaft the tappet is keyed. One of the blades of the tappet depresses a treadle which is connected to one of the leaves of the camb through the medium of the treadle bowl. Thus the leaf of the camb is depressed also. When one leaf of the camb is depressed the other leaf of the camb is raised. In the negative tappet shedding the leaf is usually raised by the camb roller. In case of a twill motion, the tappet is fixed on a supplementary shaft.

A wheel on the wyper shaft, drives the wheel on the supplementary shaft.

There are two picking wypers on two sides of the wyper shaft, the point of the wyper on one side being diametrically opposite to that of the other wyper. The wyper drives a cone stud through a certain arc of movement. The cone stud is attached to a vertical picking shaft. Thus the picking arm at the head of the picking shaft, moves quickly inwards. This motion is conveyed to the picker on the picking spindle through a picking strap. The picker pushes the shuttle to the other side of the loom along the lay. This motion is repeated on the other side by similar mechanism. The stud and the picking arm return to the former positions through the action of a spring after being acted upon by the wyper.

Two lay swords are connected to two cranks of the crank shaft by means of connecting arms. These swords are centred upon the sword shaft and support the lay. The reed is fixed to the lay. As the crank shaft rotates the lay along with the reed moves forwards and backwards. When the lay is full forward, the reed is in contact with the cloth thus driving home the weft thread.

For every revolution of the crank shaft, shedding, picking and beating up occur once. The crank circle i.e., the path of the crank is considered below :

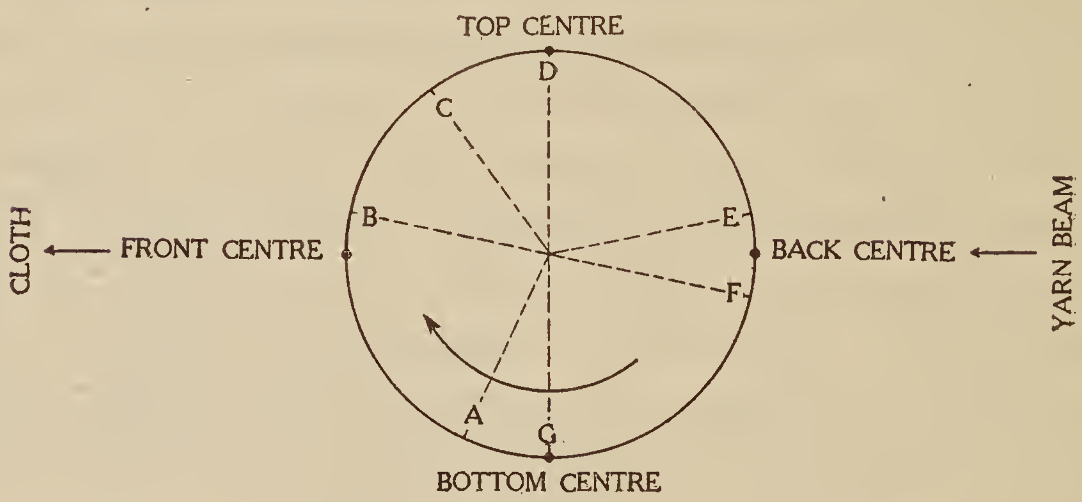
A—The leaves of the camb are level. The warp protector tongue and the buffer should be hard in contact at this point if the shuttle is removed from the shuttle box and the crank is rotated.

B—The reed is in contact with the cloth and beating

up occurs. The crank and the connecting arm are in one straight line and the reed is full forward.

C—The wypers enter on the dwell. 120° of the crank circle is assumed for dwell.

D—The picking position when the shuttle begins to



Crank Circle

move. The warp protector tongue is just clear of the buffer in its backward movement.

E—The wypers leave the dwell.

F—The reed is farthest away from the cloth. The crank and the connecting arm are in one straight line.

G—The shuttle rests in the opposite box.

In negative let-off motions, some drag is applied on the movement of the yarn beam caused by the action of the uptake and the shedding motions. Usually a chain is passed round the beam head. One end of the chain is attached to a fixed hook and the other end to the short arm of a lever through an adjustable screw. The short arm and the long arm of the lever are fixed to a shaft

which extends across the loom and has a similar short arm for the other end of the beam. The pressure on the beam head is regulated by adjusting the screw. To turn back the yarn beam the long arm of the lever is allowed to fall and the yarn beam is relieved of all pressure by the corresponding rise of the short arm.

The uptake motions in looms for jute weaving are usually positive and intermittent. The motion is in action when the lay sword is moving forward in most cases. As the lay sword comes forward it rotates a ratchet wheel C through lever and pawl arrangement. The change pinion D compounded with the ratchet wheel, drives the uptake roller wheel F through a single intermediate E. The surface of the uptake roller is either covered with perforated tin or projecting pins. The cloth passes round the uptake roller and then wound on a cloth roller which is driven by frictional contact with the uptake roller and is supported in slide brackets. In some cases five wheels are used for the drive. The change pinion compounded with the ratchet wheel, drives the cloth roller wheel through a double intermediate.

Driving shaft speed	...	R r. p. m.
Diameter of drum	...	d inches
Diameter of pulley	...	p ,,
Crank shaft pinion	...	A teeth
Wyper shaft wheel	...	B ,,
Ratchet wheel	...	C ,,
Change pinion	...	D ,,
Cloth roller wheel	...	E ,,
Diameter of cloth roller	...	e inches

Crank shaft speed (picks per min.)

$$= R \times \frac{d}{p} \text{ r. p. m.}$$

Wyper shaft speed $= R \times \frac{d}{p} \times \frac{A}{B} = k$ r. p. m.

Picks per min. $= k \times 2$

Loom Constant $= \frac{C}{1} \times \frac{E}{e \times 3{\cdot}14}$

Shots per inch $= \frac{\text{Loom constant}}{\text{Change pinion}}$

Change pinion $= \frac{\text{Loom constant}}{\text{Reqd. shots per inch}}$

Example

Driving shaft speed	...	147 r. p. m.
Diameter of drum		16 inches
Diameter of pulley	...	16 ,,
Crank shaft pinion	...	24 teeth
Wyper shaft wheel	...	48 ,,
Ratchet wheel	...	50 ,,
Change pinion	...	24 ,,
Cloth roller wheel	...	100 ,,
Diameter of cloth roller	...	$5\frac{1}{2}$ inches

Crank shaft speed $= 147 \times \frac{16}{16} = 147$ r. p. m.

Wyper shaft speed $= 147 \times \frac{16}{16} \times \frac{24}{48} = 73{\cdot}5$ r. p. m.

Picks per min. $= 73{\cdot}5 \times 2 = 147$

Loom constant $= \frac{50}{1} \times \frac{100}{5{\cdot}5 \times 3{\cdot}14} = 289{\cdot}5$

$$\text{Shots per inch} = \frac{289 \cdot 5}{24} = 12.$$

Loom—Production Calculations

Picks per min.	...	P
Loom constant	...	C
Change pinion	...	S teeth
Weight of fabric	...	W ozs. per yd.

$$\text{Shots per inch} = \frac{C}{S} = S_1$$

$$\text{Inches per min.} = \frac{P}{S_1}$$

$$\text{Yards per hour} = \frac{P \times 60}{S_1 \times 36}$$

$$\text{Yards per day of } x \text{ hours} = \frac{P \times 60 \times x}{S_1 \times 36}$$

Production per day of x hours

$$= \frac{P \times 60 \times x \times W}{S_1 \times 36 \times 16 \times 112} \text{ cwt.}$$

Example

Picks per min.	...	150
Loom constant	...	290
Change pinion	...	29 teeth
Weight of fabric	...	8 ozs. per yd.

$$\text{Shots per inch} = \frac{290}{29} = 10$$

Production per day of 10 hours

$$= \frac{150 \times 60 \times 10 \times 8}{10 \times 36 \times 16 \times 112} = 1 \cdot 12 \text{ cwt.}$$

Loom Efficiency

Picks per min. ... P
Shots per inch of the fabric ... S_1
Number of looms ... N
Actual production on the looms per week of 48 hours ... Y yds.
Theoretical production on the looms

$$= \frac{P \times 60 \times 48 \times N}{S_1 \times 36} = Y_1 \text{ yds.}$$

$$\text{Efficiency} = \frac{Y \times 100}{Y_1} \%.$$

The efficiency may be calculated in the following way :

Actual production $= Y \times 36 \times S_1$ shots

Theoretical production $= N \times P \times 60 \times 48$ shots

$$\text{Efficiency} = \frac{Y \times 36 \times S_1 \times 100}{N \times P \times 60 \times 48} \%.$$

Example

Picks per min. ... 150
Shots per inch of the fabric ... 10
Number of looms ... 80
Actual production on the looms per week of 48 hrs. ... 76800 yds.
Theoretical production on the looms

$$= \frac{150 \times 60 \times 48 \times 80}{10 \times 36} = 96000 \text{ yds.}$$

$$\text{Efficiency} = \frac{76800 \times 100}{96000} = 80 \%.$$

Actual no. of shots in the looms per week of 48 hrs. $= 76800 \times 36 \times 10 = 27648000$

Theoretical no. of shots in the looms per week of 48 hrs. $= 80 \times 150 \times 60 \times 48 = 34560000$

$$\text{Efficiency} = \frac{27648000 \times 100}{34560000} = 80\ \%.$$

Problems

(i) Calculate the loom constant from the following details:

Ratchet wheel (one tooth for each shot of weft)	...	40 teeth
Change pinion	...	30 ,,
Double intermediate	...	80/40 ,,
Cloth roller wheel	...	80 ,,
Diameter of cloth roller	...	5·125 inches

$$\text{Loom constant} = \frac{40}{1} \times \frac{80}{40} \times \frac{80}{5{\cdot}125 \times 3{\cdot}14} = 397{\cdot}70.$$

(ii) In a loom a 32 teeth change pinion produces 12·43 shots per inch. What pinion will produce 10 shots per inch?

Loom constant $= 32 \times 12{\cdot}43 = 397{\cdot}76$

Change pinion for 10 shots per inch

$$= \frac{397{\cdot}76}{10} = 39{\cdot}78 \text{ i.e., 40 teeth.}$$

(iii) In a loom the pawl takes 2 teeth of the ratchet wheel of 50 teeth for each stroke of the lay. The change pinion compounded with the ratchet wheel drives the cloth

roller wheel of 100 teeth through a single intermediate of 60 teeth. The diameter of the cloth roller is 5·5 inches. Find the change pinion for 4 shots per inch.

The ratchet wheel makes one complete revolution for $50 \div 2 = 25$ shots of weft and is therefore equivalent to 25 teeth in this case.

$$\text{Loom constant} = \frac{25}{1} \times \frac{100}{5{\cdot}5 \times 3{\cdot}14} = 144{\cdot}76$$

Change pinion for 4 shots per inch

$$= \frac{144{\cdot}76}{4} = 38{\cdot}19 \text{ i.e., 38 teeth.}$$

(iv) The picks per min. of a loom is 160. The fabric on production is 8 shots per inch, $26\frac{1}{2}$ inches wide and weighs 14·24 ozs. per yd. Find the production of the loom per day of 16 hours in cwt. at 80% efficiency.

$$\frac{160 \times 60 \times 16 \times 14{\cdot}24 \times 80}{8 \times 36 \times 16 \times 112 \times 100} = 3{\cdot}39 \text{ cwts.}$$

(v) In a loom shed 120 looms are producing a fabric of 12 shots weighing 10 ozs. per yd. The crank shaft of the looms has 150 r. p. m. Total production on these looms per week of 48 hours is 90000 yds. Calculate the loom efficiency.

$$\text{Theoretical production} = \frac{150 \times 60 \times 48 \times 120}{12 \times 36}$$

$$= 120000 \text{ yds.}$$

$$\text{Efficiency} = \frac{90000 \times 100}{120000} = 75\%.$$

The Circular Loom

The circular loom is employed to weave tubular cloth. This has the following advantages :

(i) Increased output due to higher weaving speed and less yarn breakage ;

(ii) Reduced labour cost owing to bigger shuttles, large warp yarn beams, automatic stop motion, less maintenance and absence of side seams ;

(iii) Improved quality of bags due to absence of side seams.

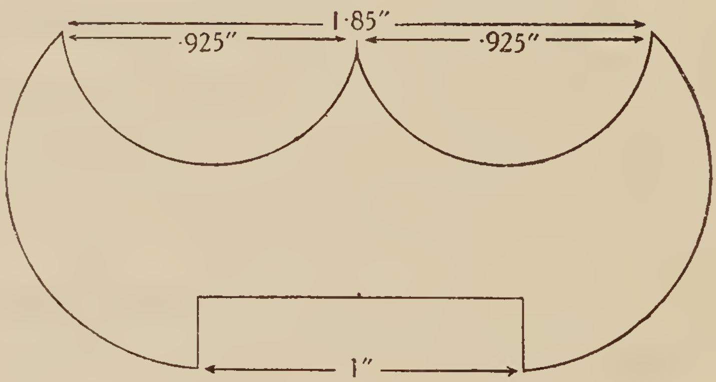
The circular loom (Fairbairn Lawson Combe Barbour) is driven by individual electric motor. The loom for plain fabric, essentially consists of the weaving ring with the accessories, four cloth beat-up assemblies, four shuttles, a reed, two sets of heddle frames, a warp yarn-tensioning system and two shedding cam shaft assemblies. The shuttles are provided with an electrical stop motion unit, a yarn-tensioning unit and a snarl-eliminator. Twenty four heddle frames make a set. The reed is provided with an automatic lubrication system. The cloth uptake motion is of continuous type. When a weft yarn breaks the uptake motion is interrupted by an automatic mechanism. Two large warp yarn beams supply warp yarn to the loom. The two warp yarn let-off motions are of negative type.

CHAPTER XIV

WARP AND WEFT CALCULATIONS

Porter Measure

The reed through which the warp yarns are drawn, determines the porter of the fabric. The reed is ascertained by the number of porters of 20 splits each in 37 inches which



Porter Measure

is the 'reed base'. The porter measure is the gauze which between its extreme points is $\frac{1}{20}$ of the reed base i.e., 1·85 inches. If 11 splits of a reed is covered by the porter measure, the reed will be called a 11-porter reed.

11 splits $\times$ 20 times the porter measure
$= 220$ splits in 37 inches of the reed

$$\text{Porter of the reed} = \frac{220}{20 \text{ splits per porter}} = 11$$

The porter measure is divided into two equal parts. Each

part is called half-porter measure and is $\frac{1}{40}$ of the reed base i.e., 0·925 inch.

$$\text{Porter of a cloth} = \frac{\text{No. of warp threads contained in the porter measure}}{\text{Threads per split of the reed}}$$

$$\text{Porter of plain hessian fabric} = \frac{\text{No. of warp threads in the porter measure}}{\text{2 threads per split}}$$

$$\text{Porter of double warp plain sacking fabric} = \frac{\text{No. of warp threads in the porter measure}}{\text{4 threads per split}}$$

$$\text{Porter of double warp twilled sacking fabric} = \frac{\text{No. of warp threads in the porter measure}}{\text{6 threads per split}}$$

Thus, a 11-porter plain hessian fabric has $11 \times 2 = 22$ warp threads in 1·85 inches or $22 \div 1·85 = 11·89$ warp threads per inch. A 8-porter double warp plain sacking fabric has $8 \times 4 = 32$ warp threads in 1·85 inches or $32 \div 1·85 = 17·29$ warp threads per inch. A 6-porter double warp twilled sacking fabric has $6 \times 6 = 36$ warp threads in 1·85 inches or $36 \div 1·85 = 19·46$ warp threads per inch. The shots of weft are usually counted by the number per inch.

Laid Length and Reed Width

'Laid length' is the length of the warp and 'finished length' is the length of the cloth produced from the laid length of the warp. The finished length is shorter than the laid length. 'Reed width' is the width of the reed

occupied by the warp threads and 'finished width' is the width of the woven cloth. The reed width is greater than the finished width. In the process of weaving, length and width are reduced due to shrinkage.

Details of Warp and Weft Calculations

Laid length	... ...	L yds.
Finished length	... ...	L_1 „
Reed width	... ...	R inches
Finished width	... ...	R_1 „
Porter of reed	... ...	P
Threads per split	... ...	N
Shots per inch	... ...	S
Count of warp	... ...	C lbs. per spyndle
Weight of cloth	... ...	W ozs. per yd.

Weight of cloth per cut $= \dfrac{L_1 \times W}{16} = A$ lbs.

Number of splits in 37 inches $= P \times 20$

Number of splits in 1 inch $= \dfrac{P \times 20}{37}$

Number of threads in 1 inch $= \dfrac{P \times 20 \times N}{37}$

Total number of warp threads $= \dfrac{P \times 20 \times N \times R}{37}$

Total length of warp in yds. $= \dfrac{P \times 20 \times N \times R \times L}{37}$

Total length of warp in spyndles $= \dfrac{P \times 20 \times N \times R \times L}{37 \times 14400}$

Total weight of warp per cut

$$= \frac{P \times 20 \times N \times R \times L \times C}{37 \times 14400} = B \text{ lbs.}$$

Weight of weft per cut $= A - B = D$ lbs.

Number of inches of weft in 1 inch of cloth $= S \times R$

Number of yds. of weft in 1 yd. of cloth $= \frac{S \times R \times 36}{36}$

Number of yds. of weft per cut $= \frac{S \times R \times 36 \times L_1}{36}$

Number of spyndles of weft per cut $= \frac{S \times R \times 36 \times L_1}{36 \times 14400} = E$

Weight of weft per spyndle $= \frac{D}{E}$ lbs.

Example

A plain hessian cloth is 125 yds. in length and 40 inches wide. The laid length and reed width were 130 yds. and 42·5 inches respectively. The cloth was woven through a 11-porter reed and contains 12 shots per inch. The count of the warp yarn is 8 lbs. per spyndle and the cloth weighs 10 ozs. per yd.

Weight of cloth $= \frac{125 \times 10}{16} = 78{\cdot}12$ lbs.

Weight of warp $= \frac{11 \times 20 \times 2 \times 42{\cdot}5 \times 130 \times 8}{37 \times 14400} = 36{\cdot}50$ lbs.

Weight of weft $= 78{\cdot}12 - 36{\cdot}50 = 41{\cdot}62$ lbs.

Number of spyndles of weft $= \frac{12 \times 42{\cdot}5 \times 36 \times 125}{36 \times 14400} = 4{\cdot}43$

Weight of weft per spyndle $= \frac{41.62}{4{\cdot}43} = 9{\cdot}39$ lbs.

Problems

(i) Find the equivalent threads per inch of a 8-porter fabric with 4 threads per split.

$$\frac{8 \times 20 \times 4}{37} = 17{\cdot}29 \text{ threads per inch.}$$

(ii) The half-porter measure covers 18 threads in the reed for a 3-leaf double warp sacking cloth. What is the porter of the cloth ?

Threads in the porter measure $= 18 \times 2 = 36$

Threads per split $= 6$

Porter of cloth $= \frac{36}{6} = 6.$

(iii) A plain hessian cloth is 40 inches wide and has 480 warp threads. What is the porter of the cloth ?

Threads per inch $= \frac{480}{40}$

Threads per porter measure $= \frac{480 \times 1{\cdot}85}{40}$

Porter of cloth $= \frac{480 \times 1{\cdot}85}{40 \times 2} = 11{\cdot}1.$

(iv) Calculate ozs. per yd. of a 11-porter, 45 in. wide fabric having 12 shots per inch. The warp is 8 lbs. per spyndle and the weft is 10 lbs. per spyndle.

Let us assume the following :

Reed width	...	47·5 inches
Laid length	...	104 yds.
Finished length	...	100 "
Threads per split	...	2

Total weight of warp

$$=\frac{11\times 20\times 2\times 47{\cdot}5\times 104\times 8}{37\times 14400}=32{\cdot}64 \text{ lbs.}$$

$$\text{Total weight of weft}=\frac{12\times 47{\cdot}5\times 100\times 10}{14400}=39{\cdot}58 \text{ lbs.}$$

Weight of 100 yds. of the fabric

$$=32{\cdot}64+39{\cdot}58=72{\cdot}22 \text{ ibs.}$$

$$\text{Ozs. per yd. of the fabric}=\frac{72{\cdot}22\times 16}{100}=11{\cdot}56.$$

(v) Calculate the spyndles of warp and weft required to weave a cut of 105 yds. of a $26\frac{1}{2}$ in. wide, 8-porter twill sacking cloth having 9 shots per inch, laid length and reed width being 110 yds. and 28 inches respectively.

$$\text{Spyndles of warp}=\frac{8\times 20\times 6\times 28\times 110}{37\times 14400}=5{\cdot}55$$

$$\text{Spyndles of weft}=\frac{9\times 28\times 105}{14400}=1{\cdot}84.$$

(vi) 8 lbs. per spyndle warp is used to manufacture a 11-porter, 40 in., 10 ozs. per yd. hessian cloth having 12 shots per inch. Calculate the percentage of warp in the fabric if the contraction in width is 2·5 inches and the contraction in length is 4%.

Reed width $=40+2{\cdot}5=42{\cdot}5$ inches

Assuming 100 yds. as laid length,

$$\text{finished length}=100\times\frac{96}{100}=96 \text{ yds.}$$

$$\text{Weight of a cut of 96 yds.}=\frac{96\times 10}{16}=60 \text{ lbs.}$$

$$\text{Weight of warp in the cut}=\frac{11\times 20\times 2\times 42{\cdot}5\times 100\times 8}{37\times 14400}$$

$$=28{\cdot}08 \text{ lbs.}$$

$$\text{Warp} = \frac{28{\cdot}08 \times 100}{60} = 46{\cdot}8\%.$$

(vii) Find the percentage of warp and weft in a 9-porter 48 in. cloth with 9 shots per inch. 8 lbs. per spyndle warp and 9 lbs. per spyndle weft are used for the fabric.

Let us assume the following :
reed width = 50 inches, laid length = 104 yds., finished length = 100 yds.

$$\text{Total weight of warp} = \frac{9 \times 20 \times 2 \times 50 \times 104 \times 8}{37 \times 14400}$$

$$= 28{\cdot}11 \text{ lbs.}$$

$$\text{Total weight of weft} = \frac{9 \times 50 \times 100 \times 9}{14400} = 28{\cdot}12 \text{ lbs.}$$

$$\text{Weight of cut} = 28{\cdot}11 + 28{\cdot}12 = 56{\cdot}23 \text{ lbs.}$$

$$\text{Warp} = \frac{28{\cdot}11 \times 100}{56{\cdot}23} = 49{\cdot}99\%$$

$$\text{Weft} = \frac{28{\cdot}12 \times 100}{56{\cdot}23} = 50{\cdot}01\%.$$

(viii) Find the count of warp for a 14·24 ozs., $26\frac{1}{2}$ in., double warp, 3-leaf sacking cloth, 6 porter, 8 shots per inch. The other details are as follows :
laid length = 115 yds., finished length = 108 yds., reed width = 28 inches, count of weft = 34 lbs. per spyndle.

$$\text{Weight of weft} = \frac{8 \times 28 \times 108 \times 34}{14400} = 57{\cdot}12 \text{ lbs.}$$

$$\text{Weight of cut} = \frac{108 \times 14{\cdot}24}{16} = 96{\cdot}12 \text{ lbs.}$$

$$\text{Weight of warp} = 96{\cdot}12 - 57{\cdot}12 = 39{\cdot}00 \text{ lbs.}$$

$$\text{Spyndles of warp} = \frac{6 \times 20 \times 6 \times 28 \times 115}{37 \times 14400} = 4{\cdot}35.$$

$$\text{Count of warp} = \frac{39{\cdot}00}{4{\cdot}35} = 8{\cdot}96 \text{ lbs. per spyndle.}$$

(ix) 125 yds. of 36 inch wide hessian cloth weigh 84·38 lbs. 9 lbs. per spyndle of warp, 12 lbs. per spyndle of weft and 11-porter reed were employed to produce the cloth. Find the number of shots per inch of the cloth.

Assuming 38 inch reed width and 130 yds. laid length,

$$\text{Weight of warp} = \frac{11 \times 20 \times 2 \times 38 \times 130 \times 9}{37 \times 14400} = 36{\cdot}72 \text{ lbs.}$$

$$\text{Weight of weft} = 84{\cdot}38 - 36{\cdot}72 = 47{\cdot}66 \text{ lbs.}$$

$$\frac{\text{Shots per inch} \times 38 \times 125 \times 12}{14400} = 47{\cdot}66 \text{ lbs.}$$

$$\text{Shots per inch} = \frac{47{\cdot}66 \times 14400}{38 \times 125 \times 12} = 12{\cdot}04.$$

(x) It is required to weave a 40 in. wide, 10 ozs. per yd. hessian cloth through a 11-porter reed, reed width being 42·5 inches, 104 yds. of warp for 100 yds. of cloth with 12 shots per inch in the cloth. The weight of warp and weft should be 4·5 ozs. and 5·5 ozs. respectively per yd. of cloth. Calculate the sizes of warp and weft yarns.

$$\frac{11 \times 20 \times 2 \times 42{\cdot}5 \times 104 \times \text{Count of warp yarn}}{37 \times 14400 \times 100} = \frac{4{\cdot}5}{16} \text{ lb.}$$

$$\text{Count of warp yarn} = \frac{37 \times 14400 \times 100 \times 4{\cdot}5}{11 \times 20 \times 2 \times 42{\cdot}5 \times 104 \times 16}$$

$$= 7{\cdot}71 \text{ lbs. per spyndle.}$$

$$\frac{12 \times 42{\cdot}5 \times 1 \times \text{Count of weft yarn}}{14400} = \frac{5{\cdot}5}{16} \text{ lb.}$$

$$\text{Count of weft yarn} = \frac{14400 \times 5{\cdot}5}{12 \times 42{\cdot}5 \times 1 \times 16}$$

$$= 9{\cdot}71 \text{ lbs. per spyndle.}$$

(xi) 100 yds. of 40 inch wide, 10 ozs. per yd. cloth weigh 63·5 lbs. Give the percentage heavy or light.

$$\text{Standard weight of cloth} = \frac{100 \times 10}{16} = 62{\cdot}5 \text{ lbs.}$$

$$\frac{(63{\cdot}5 - 62{\cdot}5) \times 100}{62{\cdot}5} = 1{\cdot}6\% \text{ heavy.}$$

(xii) 125 yds. of cloth weigh 120·25 lbs. If the cloth is 2·6% heavy what should be the standard ozs. per yd. of the cloth ?

$$\text{Actual ozs. per yd. of cloth} = \frac{120{\cdot}25 \times 16}{125}$$

$$\text{Standard ozs. per yd. of cloth} = \frac{120{\cdot}25 \times 16 \times 97{\cdot}4}{125 \times 100} = 15.$$

(xiii) A fabric has 4 threads of 3 ply 12's cotton at each selvedge. What should be the weight of cotton yarn per cut of 110 yards ?

Let us assume 115 yds. as laid length.

3 ply 12's cotton thread per cut $= 115 \times 8 = 920$ yds.

12's cotton yarn per cut $= 920 \times 3 = 2760$ yds.

Weight of $12 \times 840 = 10080$ yds. of cotton yarn $= 1$ lb.

$$\text{Weight of 2760 yds. of cotton yarn} = \frac{2760}{10080} = 0{\cdot}27 \text{ lb.}$$

Rule of "820"

This is a quick and fairly accurate method of finding the count of warp and weft yarns and ounces per yard of cloth.

(i) To find the count of weft yarn :

$$\text{Count of weft yarn} = \frac{A - B}{\text{Shots per inch}}$$

$$A = \frac{820 \times \text{Ozs. per yd. of fabric}}{\text{Width of fabric}}$$

For plain fabrics, $B =$ Porter $\times$ Count of warp yarn.

For double warp plain fabrics, $B =$ Porter $\times$ Count of warp yarn $\times$ 2.

For double warp 3-leaf sacking fabrics, $B =$ Porter $\times$ Count of warp yarn $\times$ 3.

Example

(a) 40 inch wide hessian cloth, 10 ozs. per yd., 11 porter, 13 shots per inch, 8 lbs. per spyndle of warp yarn. To find the count of weft yarn :

$$A = \frac{820 \times 10}{40} = 205$$

$$B = 11 \times 8 = 88$$

$$\text{Count of weft yarn} = \frac{205 - 88}{13} = 9 \text{ lbs. per spyndle.}$$

(b) 26 inch wide double warp plain salts, 10·8 ozs. per yd., 6 porter, 8 shots per inch, $9\frac{1}{2}$ lbs. per spyndle of warp yarn. To find the count of weft yarn :

$$A = \frac{820 \times 10{\cdot}8}{26} = 340{\cdot}61$$

$$B = 6 \times 9{\cdot}5 \times 2 = 114$$

$$\text{Count of weft yarn} = \frac{340{\cdot}61 - 114}{8} = 28{\cdot}33 \text{ lbs. per spyndle.}$$

(c) 30 inch wide double warp twilled grain sacks, 14 ozs. per yd., 6 porter, 7 shots per inch, $9\frac{1}{2}$ lbs. per spyndle of warp yarn. To find the count of weft yarn :

$$A = \frac{820 \times 14}{30} = 382{\cdot}66$$

$B = 6 \times 9{\cdot}5 \times 3 = 171$

Count of weft yarn $= \dfrac{382{\cdot}66 - 171}{7} = 30{\cdot}24$ lbs. per spyndle.

(ii) To find the count of warp yarn :

Count of warp yarn $= \dfrac{A - B}{\text{Porter}}$

$A = \dfrac{820 \times \text{Ozs. per yd. of fabric}}{\text{Width of fabric}}$

$B =$ Shots per inch $\times$ Count of weft yarn.

Example

40 inch wide hessian cloth, 10 ozs. per yd., 11-porter, 13 shots per inch, 9 lbs. per spyndle of weft yarn. To find the count of warp yarn :

$A = \dfrac{820 \times 10}{40} = 205$

$B = 13 \times 9 = 117$

Count of warp yarn $= \dfrac{205 - 117}{11} = 8$ lbs. per spyndle.

(iii) To find ozs. per yd. of fabric :

Ozs. per yd. of fabric $= \dfrac{(C \times P + S \times C_1) \times W}{820}$

P = Porter of cloth
S = Shots per inch
W = Width of cloth
C = Count of warp yarn in lbs. per spyndle
C_1 = Count of weft yarn in lbs. per spyndle.

Example

40 inch wide hessian cloth, 11 porter, 13 shots per inch, 8 lbs. per spyndle of warp yarn, 9 lbs. per spyndle of weft yarn. To find ozs. per yd. of fabric :

$$\text{Ozs. per yd. of fabric} = \frac{(8 \times 11 + 13 \times 9) \times 40}{820} = 10.$$

Spinning Spindles per Loom

Number of warp threads in the fabric ... N

Production per loom per hour ... P yds.

Warp yarn required per loom per hour

$= N \times P = P_1$ yds. (neglecting shrinkage)

Spinning spindle speed (for warp) ... R_1 r.p.m.

Turns per inch for warp yarn. ... T

Production per spinning spindle per hour at 100% efficiency $= \dfrac{R_1 \times 60}{T \times 36}$ yds.

Production per spinning spindle per hour at 80% efficiency $= \dfrac{R_1 \times 60 \times 80}{T \times 36 \times 100} = P_2$ yds.

$$\text{Warp spindles per loom} = \frac{P_1}{P_2}$$

Reed width of the fabric ... R inches

Production per loom per hour ... P yds.

Shots per inch ... S

Weft yarn required per loom per hour

$= R \times P \times S = P_3$ yds.

Spinning spindle speed (for weft) ... R_2 r.p.m.

Turns per inch for weft yarn ... T_1

Production per spinning spindle per hour at 100%

$$\text{efficiency} = \frac{R_2 \times 60}{T_1 \times 36} \text{ yds.}$$

Production per spinning spindle per hour at 80%

$$\text{efficiency} = \frac{R_2 \times 60 \times 80}{T_1 \times 36 \times 100} = P_4 \text{ yds.}$$

$$\text{Weft spindles per loom} = \frac{P_3}{P_4}$$

Example

A 40 inch wide fabric weighs 10 ozs. per yd. and has 12 shots per inch. Total number of warp threads in the fabric is 504. Average production per loom is 16 yds. per hour. Warp spinning spindles have 2800 revs. per min. and twist on warp yarn is 4·00 turns per inch. Weft spinning spindles have 2600 revs. per min. and twist on weft yarn is 3·40 turns per inch. To find spinning spindles per loom :

Warp yarn required per loom per hour

$$= 504 \times 16 = 8064 \text{ yds.}$$

Allowing 4% for shrinkage in weaving, warp yarn

$$\text{required} = 8064 \times \frac{104}{100} = 8386{\cdot}56 \text{ yds.}$$

Production per spinning spindle (warp) per hour at

$$80\% \text{ efficiency} = \frac{2800 \times 60 \times 80}{4 \times 36 \times 100} = 933{\cdot}33 \text{ yds.}$$

$$\text{Warp spindles per loom} = \frac{8386{\cdot}56}{933{\cdot}33} = 8{\cdot}99$$

Allowing 4% for wastage, warp spindles per loom

$$= 8{\cdot}99 \times \frac{104}{100} = 9{\cdot}35$$

Weft yarn required per loom per hour

$$= 42{\cdot}5 \times 16 \times 12 = 8160 \text{ yds.}$$

Production per spinning spindle (weft) per hour at 80%

$$\text{efficiency} = \frac{2600 \times 60 \times 80}{3{\cdot}4 \times 36 \times 100} = 1019{\cdot}61 \text{ yds.}$$

$$\text{Weft spindles per loom} = \frac{8160}{1019{\cdot}61} = 8$$

Allowing 4% for wastage, weft spindles per loom

$$= 8 \times \frac{104}{100} = 8{\cdot}32.$$

CHAPTER XV

FINISHING

Finishing

The jute fabric after the loom state, is subjected to a course of treatment to improve its appearance. This course of treatment is known as finishing. Hessian fabrics when to be delivered in long-length form, may be subjected to all or many of the following processes :—

(i) Inspecting
(ii) Cropping
(iii) Damping
(iv) Calendering
(v) Chesting
(vi) Mangling
(vii) Measuring
(viii) Crisping
(ix) Lapping
(x) Packing.

Sacking fabrics are usually made into bags. Bags are made of hessian fabrics also. All fabrics for making bags may be subjected to the following processes :—

(i) Inspecting
(ii) Damping
(iii) Calendering
(iv) Measuring

(v) Cutting
(vi) Sewing
(vii) Packing.

Inspecting

The jute fabrics are examined to detect faults which may occur in the process of weaving and then the faults are repaired by darning or otherwise. The following are the usual faults which may occur in the process of weaving :—

(i) Broken warps
(ii) Broken wefts
(iii) Gaws (missing weft threads)
(iv) Shotting bar (closely packed weft yarn at the change of the shuttle)
(v) Snarls (weft yarn in lumps)
(vi) Scobbs (warp yarn not interlaced with a few weft yarns)
(vii) Reed marks (warp yarns in splitfuls)
(viii) Uneven selvedges (due to weft dragging or locking)
(ix) Smashes (breakage of warp yarns by the shuttle)
(x) Pin marks (due to bent, blunt or very long pins of the pin roller).

Cropping

Cropping is the process whereby the short projecting fibres are removed from the surface of the cloth by sharp cutting spirals. This process reduces the hairiness of the fabric and makes it more lustrous. The cropping machine essentially consists of one or more cutting spirals. Each cutting spiral revolves against a fixed blade. In a double

spiral cropper (Urquhart, Lindsay) the cloth is tensioned as it passes over and under a series of rails. Then it passes over the guide plate and approaches the first spiral. The protruding fibres are caught between the fixed blade and the revolving spiral and removed from the surface of the cloth. The action is repeated in front of the second spiral and the cloth is finally pulled by a set of three drawing and pressing rollers.

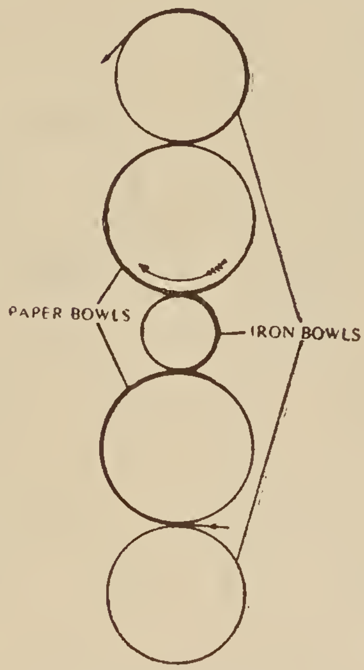
Damping

Damping imparts the desired firmness and crispness to the finished fabric. The drawing and pressing rollers pull the fabric rapidly through the machine where sprays of water act on both sides of the fabric. The quantity of moisture applied to the fabric may be regulated by suitable valve arrangement. At the delivery end a faking board deposits the fabric on the floor in loose folds.

Calendering

Calendering is the process which flattens the surface of the fabric and thus puts a skin on it. In this process the fabric is passed under pressure between two or more alternate iron and compressed-paper covered bowls. The number of bowls varies from three to nine. The five-bowl calender is the common type. The central iron bowl is usually heated by steam. Two paper bowls are in contact with the central iron bowl or the steam cylinder. The top paper bowl is in contact with the top iron bowl and the bottom paper bowl is in contact with the bottom iron bowl. The cloth is held in tension by means of rails. It

passes between bottom iron bowl and bottom paper bowl, between bottom paper bowl and steam cylinder, between



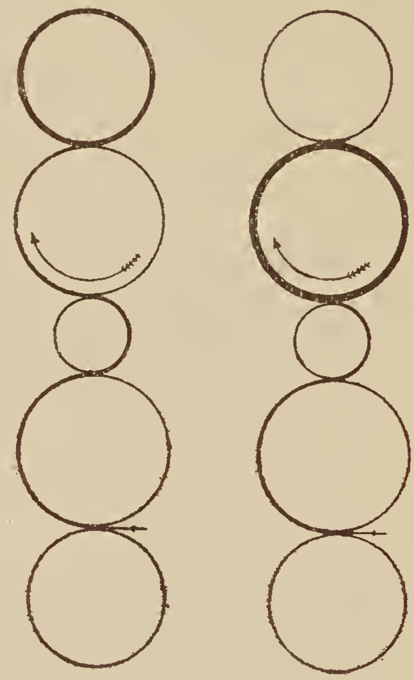
Calender Finish

steam cylinder and top paper bowl, between top paper bowl and top iron bowl and is finally delivered over the top iron bowl. The calender (Robertson, Orchar) may be driven by one of the two belt drives. One drive is through open belt and the other through crossed belt. One drive is for reverse motion. The pinion on the pulley shaft drives the steam cylinder wheel. The calender is provided with a system of levers and weights for the application of necessary pressure.

Chesting

Chesting reduces the interestices between the threads of the fabric. In this process the fabric after passing between all the bowls of a calender from bottom to top, is wound upon itself on either of the two upper bowls.

Then the fabric is subjected to a heavy pressure for a few minutes. For light chesting the fabric is wound on



Light Chest Finish Heavy Chest Finish

the top iron bowl and for heavy chesting the fabric is wound on the top paper bowl. The stripping roller strips the fabric from the chesting bowl.

Calendering and Chesting reduce the width of the fabric. This reduction in width is accompanied by an increase in length.

Mangling

Mangling reduces the size of the interstices between the threads more effectively than chesting. This process imparts a full, soft and mellow finish to the fabric. The calendered fabric is rolled on a steel pin which is rotated backwards and forwards between the bowls of a hydraulic mangle under a continuous heavy pressure.

A hydraulic mangle consists of two ponderous mangling bowls. The mangle pin with rolled fabric is placed

between these bowls. The bottom mangling bowl receives the drive through gearing. The mangling pin with the fabric is driven by the bottom mangling bowl through frictional contact. The pin, again, drives the top mangling bowl by frictional contact. The top bowl may also be driven by gearing from the bottom bowl. During the process, the direction of rotation of the bowls and the pin is reversed through a self-acting reversing gear. Hydraulic pressure is applied by means of an accumulator. The machine is provided with cloth beaming and stripping motions.

Measuring

The fabric after calendering, chesting or mangling is measured in a measuring machine. A measuring machine (Urquhart, Lindsay) essentially consists of a measuring roller and the drawing and pressing rollers. The circumference of the measuring roller is one yard and the surface is provided with perforated metal strips or with a few short pins to engage with the fabric. The drawing roller is driven by a fast and loose pulley. The fabric passes over the guide rollers, then around the measuring roller and is finally drawn by the drawing and pressing rollers. The to-and-fro motion of a faking board, causes the fabric to drop in loose folds. The drawing roller conveys the motion to a crank shaft through belt drive. The cranks and the connecting arms drive the faking board. A clock driven from the measuring roller through suitable gearing, indicates the number of yards of fabric which pass through the machine.

Crisping

Crisping is the doubling of a fabric, selvedge to selvedge, along its entire length. Crisping is done to reduce the width of too wide fabrics to about half the original width. The machine in which the operation is carried out is known as a crisping machine. Usually after crisping the fabric is rolled in a rolling machine. Crisping and rolling may be done in one machine also. Rolled fabrics are usually 'stitched'.

Lapping

The jute fabrics are usually lapped full width after measuring. Lapping is the operation of doubling the fabric repeatedly upon itself into folds of predetermined length. The lapping machine (Hacking) essentially consists of a lapping table, two movable grip rails on both ends of the table and a knife carrier having two folding knives. The fabric is tensioned by rails. The knife carrier is driven from one side to the other side of the machine between the grip rails. The pinion on the pulley shaft drives the hollow shaft wheel through a double intermediate. As the hollow shaft revolves the motion is conveyed to the knife carrier through crank, connecting arm and folding lever. As the knife moves it draws the fabric until it reaches one of the grip rails. The grip rail is raised to allow the folding knife to enter with a fold of the fabric. When one grip rail is raised the other is locked in position to retain a fold until the folder returns with another layer of fabric. The knife carrier is tilted by suitable mechanism as it changes its direction of

motion during its passage to place the knife parallel to the face of the grip and close to the table or the last layer of cloth so that the knife with the fabric freely enters between the table and the rail. The table is pressed against the grip rails by a mechanism consisting of spiral springs and scroll cams. As the number of folds are increasing during the process of lapping the table is gradually depressed. Lapped fabrics are 'tied'.

Cutting

The fabrics which are to be made into bags are cut into pieces of suitable length in a cutting machine. A cutting machine (Urquhart, Lindsay) essentially consists of a measuring roller, pressing roller, a moving knife and a fixed knife. The fast and loose pulleys are employed to put the machine in action or out of action. A pinion on the pulley shaft drives the measuring roller wheel which in turn drives the pressing roller wheel. The pinion on the other end of the measuring roller drives the moving knife shaft wheel through a single intermediate and a double intermediate. The fabric is tensioned by rails, guided by guide rollers, passes round the measuring roller, under the pressing roller and finally cut between the fixed knife and the moving knife. As the measuring roller draws the fabric continuously the fabric is held by a board when the actual cutting takes place. Two cams on both sides of the moving knife shaft conveys the motion to the board.

Sewing

There are three principal methods of formation of bags from jute fabric.

(i) The width of the bag is made from the width of the fabric. The width of the fabric should be equal to the width of the bag. Usually the former is slightly wider than the width of the bag to allow for sewing at the sides. The raw edges of the cut piece are hemmed and then doubled hemmed end to hemmed end. The sides (selvedges) are overhead sewn. The length of the bag is along the warp of the fabric. The length of the cut piece is equal to twice the length of the bag plus 3 inches for hemming.

Example

A. twill bags—44″ × 26½″ hd. ex.—26½″ cloth

Length of cut piece = 2 × 44 + 3 = 91 inches.

(ii) The width of the bag is made from the width of the fabric. The width of the bag should be equal to half the width of the fabric. Usually the width of the fabric is slightly wider than double the width of the bag to allow for sewing at the side. The raw side of the fabric which forms the top of the bag is hemmed. The fabric is doubled selvedge to selvedge. The selvedges are overhead sewn and form one side of the bag. The raw edge which forms the bottom of the bag is laid-in and overhead sewn. The length of the bag is along the warp of the fabric. The length of the cut piece is equal to the length of the bag plus 3 inches for hemming at the top and lay-in at the bottom.

Example

Wheat bags—36″ × 22″ hd. ex—44″ cloth

Length of cut piece = 36 + 3 = 39 inches.

(iii) The length of the bag is made from the width of the fabric. The length of the bag is equal to the width of

the fabric. The cut piece is doubled raw edge to raw edge. The raw edges form one side of the bag. These are laid-in and overhead sewn. One selvedge forms the top of the bag and the other which forms the bottom of the bag is overhead sewn. The length of the bag is along the weft of the fabric. The length of the cut piece is equal to twice the width of the bag plus 3 inches for lay-in.

Example

Bran bags—49″ × 30″ selv. ex.—49″ cloth

Length of cut piece $= 2 \times 30 + 3 = 63$ inches.

The following types of seam and hem are usually employed for the fabrication of jute bags :

(i) Plain seam—sewn through two thicknesses of fabric. After sewing the bag is turned. Type of stitching is 'union'.

(ii) Counterlaid seam—sewn through four thicknesses of fabric. After sewing the bag is turned. Type of stitching is 'union'.

(iii) Overhead seam

(a) On selvedges—sewn through two thicknesses of fabric.

(b) On raw edges—sewn through four thicknesses of fabric. After sewing the bag is not turned. Type of stitching is 'overhead'.

(iv) Herakles

(a) On selvedges—sewn through two thicknesses of fabric.

(b) On raw edges—sewn through four thicknesses of fabric. After sewing the bag is not turned. Type of stitching is 'Herakles'.

(v) Hemming

(a) On raw edges at mouth—the fabric is turned twice.

(b) On selvedges at mouth—the fabric is turned once. Type of stitching is 'union'.

Packing

The pieces of the jute cloth after lapping or the bags after bundling are made into bales for export in hydraulic presses. A hydraulic press essentially consists of a massive top plate supported by four heavy columns. The lower moving plate is fixed to the upper part of one or two rams which move up and down in cast steel cylinder. The goods are placed in the lower table and covered with pack sheet. As the cylinder is filled with water under pressure the ram and the lower table rise and the goods are pressed to the required volume. Then the pack sheet is stitched and the binding iron hoops are fixed round the bale. An exhaust valve is opened and the lower table begins to come down. After this the bale is removed from the press. Hydraulic pumps are essential to apply the heavy pressure to the hydraulic presses for packing purposes. The usual pressure per square inch exerted on the ram varies between $\frac{1}{2}$ ton to $1\frac{1}{2}$ ton. In a few cases even higher pressure is applied.

Gunny bales are pressed and packed on a basis of 50 cubic feet per ton.

$$\frac{(\text{Nett weight} + \text{tare}) \times 50}{2240} = \text{Cubic feet dead weight measurement.}$$

Example

A bale contains 2000 yds. of 40 in. wide, 10 ozs. per yd. hessian cloth.

$$\text{Nett weight} = \frac{2000 \times 10}{16} = 1250 \text{ lbs.}$$

$$\text{Dead weight measurement} = \frac{(1250 + 25) \times 50}{2240} = 28{\cdot}46 \text{ cubic feet.}$$

Problems

(i) In a cropping machine cutting spirals are driven in the following way :

Driving shaft speed	...	260 r. p. m.
Diameter of drum	...	20 inches
Diameter of pulley	...	15 ,,
Diameter of cutting spiral driving pulley		17 ,,
Diameter of cutting spiral pulley	...	5 ,,

Find the speed of the cutting spiral.

$$260 \times \frac{20}{15} \times \frac{17}{5} = 1178{\cdot}67 \text{ r. p. m.}$$

(ii) Find the folding speed per minute of a lapping machine from the following details :

Driving shaft speed	...	141·25 r. p. m.
Diameter of drum	..	20 inches
Diameter of pulley	...	13 ,,
Pulley shaft pinion	...	22 teeth
Double intermediate	...	45/22 ,,
Hollow shaft wheel (to folder)	...	120 ,,

$$141{\cdot}25 \times \frac{20}{13} \times \frac{22}{45} \times \frac{22}{120} = 19{\cdot}5 \text{ double folds}$$

or, 39 single folds per min.

(iii) Find the speed of the measuring roller and the moving knife of a bag cutting machine from the following details :

Driving shaft speed	...	147 r. p. m.
Diameter of drum	...	16 inches
Diameter of pulley	...	15 ,,
Pulley shaft pinion	...	12 teeth
Measuring roller wheel	...	76 ,,
Diameter of measuring roller	...	23 inches
Pinion on off end of measuring roller	...	72 teeth
Double intermediate	...	75/68 ,,
Knife shaft wheel	...	68 ,,

Measuring roller speed $= 147 \times \frac{16}{15} \times \frac{12}{76} \times \frac{23 \times 3{\cdot}14}{1}$

$= 1788{\cdot}16$ inches per min.

Knife speed $= 147 \times \frac{16}{15} \times \frac{12}{76} \times \frac{72}{75} \times \frac{68}{68} = 23{\cdot}77$ strokes per min.

(iv) How many yards of 49 in. wide cloth is required to make 1000 pieces $49'' \times 30''$ selv. Bran bags ?

Cut piece per bag $= 2 \times 30 + 3 = 63$ inches

$\frac{1000 \times 63}{36} = 1750$ yds. of cloth.

(v) $44'' \times 26\frac{1}{2}''$ hemmed B. twill bag is made from a cloth which is $26\frac{1}{2}''$ wide. If each bag weighs $2\frac{1}{4}$ lb. find the ozs. per yd. of the cloth neglecting sewing.

Cut piece per bag $= 2 \times 44 + 3 = 91$ inches

91 inches weigh 36 ozs.

1 yd. weighs $\frac{36 \times 36}{91} = 14{\cdot}24$ ozs.

(vi) One cut of cloth weighing 78 lbs. receives 5% moisture during damping. During calendering the cut loses 3% weight. What would be the weight of the cut after calendering ?

$$78 \times \frac{105}{100} = 81{\cdot}9 \text{ lbs. after damping}$$

$$81{\cdot}9 \times \frac{97}{100} = 79{\cdot}44 \text{ lbs. after calendering.}$$

(vii) A gunny bale contains 300 pcs. $41'' \times 23''$ hemmed $2\frac{1}{4}$ lbs. corn sacks. The tare for pack sheet and hoops is 15 lbs. The measurement of the bale is $43'' \times 25{\cdot}5'' \times 25''$. Find the percentage over or under the dead weight measurement.

Nett weight $= 300 \times 2{\cdot}25 = 675$ lbs.

$$\text{Dead weight measurement} = \frac{(675 + 15) \times 50}{2240}$$

$$= 15{\cdot}4 \text{ cubic feet}$$

$$\text{Actual capacity of the bale} = \frac{43 \times 25{\cdot}5 \times 25}{1728}$$

$$= 15{\cdot}86 \text{ cubic feet}$$

$$\frac{(15{\cdot}86 - 15{\cdot}4) \times 100}{15{\cdot}4} = 2{\cdot}98\% \text{ over.}$$

(viii) Contract received for 100000 yds. 11 porter 12 shots, 45 in. wide, 10 ozs. per 40 in. hessian cloth—2000 yds. iron bound—due date 31. 3. 60. What should be the last date to start beaming if only one dressing machine be employed ?

Average yds. per cut $= 125$

$$\text{Total order} = \frac{100000}{125} = 800 \text{ cuts}$$

Average production per dressing machine per day
$= 5$ beams $= 50$ cuts (10 cuts per beam)

$\frac{800}{50} = 16$ days beaming

Average production per loom per day $= 1$ cut

Last beam will run for 10 days.

$16 + 10 = 26$ days for beaming and weaving

Working days per week $= 6$

4 weeks and 2 days for beaming and weaving

Beaming must be started on 1. 3. 60. to get the order ready.

(ix) Contract received on 15. 3. 60. for 15000 pcs. B. twill sacks—$44'' \times 26\frac{1}{2}''$ hemmed $2\frac{1}{4}$ lbs. (6×8, $26\frac{1}{2}''$, 3 blue stripes, 14·24 ozs. per yd. cloth)—300 bags I. B. Folded—due date 31. 3. 60. How many looms to be employed to finish the order in time?

Cut length per bag $= 2 \times 44 + 3 = 91$ inches

Cloth required for 15000 bags $= \frac{15000 \times 91}{36}$

$= 37917$ yds.

Allowing 1% for wastage, cloth required $= 38296$ yds.

Average yds. per cut $= 108$

Total order $= \frac{38296}{108} = 355$ cuts

Average production per beaming machine
$= 13$ beams $= 91$ cuts (7 cuts per beam)

$\frac{355}{91} = 4$ days beaming

For sewing and packing 2 days are allowed after the last cut is out.

12 working days upto 31. 3. 60.

6 days may be allowed for beaming, sewing and packing.

6 days are left for weaving.

Average production per loom per day $= 240$ yds.

Average production per loom for 6 days

$$= 240 \times 6 = 1440 \text{ yds.}$$

No. of looms required $= \dfrac{38296}{1440} = 27.$

(x) Contract received on 1. 3. 60. for 20000 bags—plain heavy Cees $40'' \times 28''$ hemmed, 8 porter 9 shots, $2\frac{1}{4}$ lbs. per bag—400 pcs. I. B. Folded.

On that day 40 looms were on that quality. How many days were required to get the order ready ?

Cut length per bag $= 2 \times 40 + 3 = 83$ inches

Cloth required for 20000 bags $= \dfrac{20000 \times 83}{36}$

$$= 46111 \text{ yds.}$$

Allowing 1% for wastage, cloth required $= 46572$ yds.

As this quality was on, no allowance was made for beaming.

Average production per loom per day $= 220$ yds.

Average production of 40 looms per day

$$= 220 \times 40 = 8800 \text{ yds.}$$

Days required for weaving $= \dfrac{46572}{8800} = 5{\cdot}3$ say 6 days

2 days were allowed for sewing and packing.

$6 + 2 = 8$ days were required to get the order ready.

CHAPTER XVI

MISCELLANEOUS PROBLEMS

(i) Calculate the number of 4″ and 6″ ordinary spinning frames (78 spindles per 4″ frame and 64 spindles per 6″ frame) to feed a loom shed having 910 hessian looms and 478 sacking looms.

As per working time agreement of Indian Jute Mills Association,

22 – 4″ ordinary spindles per loom for hessian warp and weft,
22 – 4″ ,, ,, ,, ,, ,, sacking warp,
8·5 – 6″ ,, ,, ,, ,, ,, ,, weft.

910 × 22 = 20020 – 4″ ordinary spindles for hessian warp and weft,
478 × 22 = 10516 – 4″ ,, ,, ,, sacking warp,
478 × 8·5 = 4063 – 6″ ,, ,, ,, ,, weft.

Total 4″ spindles required = 20020 + 105 16 = 30536

$$\frac{30536}{78} = 391 - 4'' \text{ spinning frames}$$

$$\frac{4063}{64} = 63 - 6'' \text{ spinning frames.}$$

(ii) Find the number of $4\frac{1}{4}''$ pitch and $5\frac{1}{2}''$ pitch sliver spinning frames (100 spindles per $4\frac{1}{4}''$ pitch frame and 80 spindles per $5\frac{1}{2}''$ pitch frame) to supply 1002 hessian looms and 292 sacking looms.

$1002 \times 22 = 22044 - 4''$ ordinary spindles for hessian warp and weft,

$292 \times 22 = 6424 - 4''$ ordinary spindles for sacking warp,

$292 \times 8{\cdot}5 = 2482 - 6''$,, ,, ,, ,, weft.

Total $4''$ spindles required $= 22044 + 6424 = 28468$

1 sliver spinning spindle is equivalent to 1·33 ordinary spindles, when the preparing machinery is fully modernised.

28468 ordinary $4''$ spindles

$$= \frac{28468}{1{\cdot}33} = 21404 - 4\tfrac{1}{4}'' \text{ pitch sliver spinning spindles}$$

$$= \frac{21404}{100} = 214 - 4\tfrac{1}{4}'' \text{ pitch sliver spinning frames}$$

2482 ordinary $6''$ spindles

$$= \frac{2482}{1{\cdot}33} = 1866 - 5\tfrac{1}{2}'' \text{ pitch sliver spinning spindles}$$

$$= \frac{1866}{80} = 23 - 5\tfrac{1}{2}'' \text{ pitch sliver spinning frames}$$

1 sliver spinning spindle is equivalent to 1·25 ordinary spindles, when the old carding machines are used.

28468 ordinary $4''$ spindles

$$= \frac{28468}{1{\cdot}25} = 22774 - 4\tfrac{1}{4}'' \text{ pitch sliver spinning spindles}$$

$$= \frac{22774}{100} = 228 - 4\tfrac{1}{4}'' \text{ pitch sliver spinning frames}$$

2482 ordinary $6''$ spindles

$$= \frac{2482}{1{\cdot}25} = 1986 - 5\tfrac{1}{2}'' \text{ pitch sliver spinning spindles}$$

$$= \frac{1986}{80} = 25 - 5\tfrac{1}{2}'' \text{ pitch sliver spinning frames.}$$

(iii) If a system of sacking looms are sealed, how

many ordinary 4″ spinning frames (72 spindles per frame) and 6″ spinning frames (58 spindles per frame) would be stopped ?

Let us assume 40 sacking looms for a system.

$40 \times 22 = 880 - 4''$ spindles for sacking warp

$40 \times 8{\cdot}5 = 340 - 6''$ „ „ „ weft

$\frac{880}{72} = 12 - 4''$ spinning frames for sacking warp

$\frac{340}{58} = 6 - 6''$ „ „ „ „ weft

$12 - 4''$ and $6 - 6''$ spinning frames would be stopped.

(iv) The production in a jute mill for a month is 1000 tons. The details of the expenses are given below :

Jute—Rs. 620000, Stores—Rs. 60000, Wages—250000, Coal and Electricity—Rs. 20000, Insurance—Rs. 20000, Transport—Rs. 10000, Health and Welfare—Rs. 10000, Other Expenses—Rs. 10000. Find the cost per ton of production.

By adding all these expenses we get the total expense as Rs. 1000000.

$$\text{Cost per ton of production} = \frac{1000000}{1000} = \text{Rs. } 1000.$$

(v) Calculate the number of workers per loom of a jute mill having 750 hessian looms and 250 sacking looms. 2900 workers are employed in the mill.

Total number of looms $= 750 + 250 = 1000$

$$\text{Workers per loom} = \frac{2900}{1000} = 2{\cdot}9.$$

(vi) There was shortage of yarn in a jute mill. By employing 50 extra hands in the batching, preparing,

spinning and winding departments the shortage was made up and the weaving production was increased by 100 mds. per week. The average batch price was Rs. 25 per maund. The cost per md. of production was Rs. 38. The average wages per worker was Rs. 15 per week. Find the gain or loss per week.

Cost per maund of production excluding cost of jute $= 38 - 25 =$ Rs. 13 assuming 1 maund of jute produces 1 maund of fabric.

Gain for the increase of production $= 100 \times 13 =$ Rs. 1300

Wages of 50 extra hands $= 50 \times 15 =$ Rs. 750

Gain per week $= 1300 - 750 =$ Rs. 550.

(vii) The average quantity of line cuttings in a batching department is 100 mds. per day of 8 hours. The average price of long jute is Rs. 25 per md. The average price of bale cuttings is Rs. 15 per md. The quantity of line cuttings is reduced by 5 mds. per day by modifying the system of piling. 10 extra hands are employed for this method of piling. The average wages of each worker is Rs. 2 per day of 8 hours. Find the loss or gain per week of 6 days.

Difference in the price of long jute and cuttings $= 25 - 15 =$ Rs. 10

Saving per day due to reduction of line cuttings $= 10 \times 5 =$ Rs. 50

Increase in expenses per day due to extra hands $= 2 \times 10 =$ Rs. 20

Gain per day $= 50 - 20 =$ Rs. 30

Gain per week $= 30 \times 6 =$ Rs.180.

(viii) 900 mds. of jute was issued to a batching department on a certain day. The average batch price was Rs.

24 per md. An increase of 100 mds. of cuttings on the issue changed the average batch price to Rs. 23·10 per md. What was the price of cuttings per md.?

Price of 900 mds. of jute $= 900 \times 24 =$ Rs. 21600

Price of 1000 mds. of jute (including cuttings)

$= 1000 \times 23{\cdot}10 =$ Rs. 23100

Price of 100 mds. of cuttings

$= 23100 - 21600 =$ Rs. 1500

Price of cuttings per md. $= \frac{1500}{100} =$ Rs. 15.

(ix) 3 rolls of white jute, 4 rolls of daisee and mesta, 2 rolls of cuttings and 1 roll of rope and thread waste were fed on a finisher card. Daisee and mesta were mixed in equal proportion on the breaker card feed table. The roll of rope and thread waste consists of equal quantities of rope and thread waste. Find the mixture on the finisher card.

$3 + 4 + 2 + 1 = 10$ rolls on the finisher card.

10 rolls is equivalent to 100% of the batch. So 1 roll is equivalent to 10% of the batch.

White jute 3 rolls $= 3 \times 10 = 30\%$

Daisee and mesta 4 rolls $= 4 \times 10 = 40\%$

As the proportion of daisee and mesta is equal,

Daisee $= 20\%$

Mesta $= 20\%$

Cuttings 2 rolls $= 2 \times 10 = 20\%$

Thread waste and rope 1 roll $= 10\%$

As the proportion of thread waste and rope is equal,

Thread waste $= 5\%$

Rope $= 5\%$.

(x) The average batch price is Rs. 25 per md. If the batch price is reduced by Re. 0·5 per md. and the fabric is 2% heavy how the profit would be affected in a contract of 50 tons ?

$50 \times 27{\cdot}27 = 1363{\cdot}5$ mds. of production

Assuming jute issue same as production,

Price of jute $= 1363{\cdot}5 \times 25 =$ Rs. 34087·50

Price of jute when the fabric is 2% heavy

$$= 1363{\cdot}5 \times \frac{102}{100} \times 24{\cdot}5 = \text{Rs. } 34073{\cdot}86$$

Gain $= 34087{\cdot}50 - 34073{\cdot}86 =$ Rs. 13·64.

(xi) Stock of material in process in a jute mill at the end of the month of January was 13500 mds. During the month of February jute issue was 35500 mds. Stock of material at the end of the month of February was 13000 mds. Production for the month was 35000 mds. Calculate the consumption of jute per md. of production for the month of February.

Actual consumption of jute during the month of February $= 13500 + 35500 - 13000 = 36000$ mds.

Consumption of jute per md. of production

$$= \frac{36000}{35000} = 1{\cdot}03 \text{ md.}$$

(xii) The ozs. per yd. of a hessian fabric is 10 and the moisture regain is 22%. What would be the ozs. per yd. at 17% regain ?

$$\frac{10 \times (100 + 17)}{(100 + 22)} = 9{\cdot}59 \text{ ozs. per yd.}$$

(xiii) The actual weight of a bag is 38 ozs. and the

measured moisture content is 25% regain. Find the actual weight of the bag at 20% regain.

$$\frac{38 \times (100+20)}{(100+25)} = 36 \cdot 48 \text{ ozs.}$$

(xiv) In a very dry day, the rate of evaporation is very high in a sliver spinning shed. The regain of hessian warp yarn at the spinning frame is 12%. The weight of the yarn should be 8 lbs. at 16% regain. To what weight should the yarn be spun to avoid unnecessary consumption of jute ?

$$\frac{8 \times (100+12)}{(100+16)} = 7 \cdot 72 \text{ lbs.}$$

(xv) The standard weight of a cut of hessian cloth is 80 lbs. at 17% regain. The actual weight of a cut received from the loom is 2% heavy. The regain of the cut is 20%. Find the percentage heavy or light.

Actual weight of the cut at 20% regain

$$= 80 \times \frac{102}{100} = 81 \cdot 6 \text{ lbs.}$$

Weight of the cut at 17% regain

$$= \frac{81 \cdot 6 \times (100+17)}{(100+20)} = 79 \cdot 56 \text{ lbs.}$$

$80 - 79 \cdot 56 = 0 \cdot 44$ lb. light

$$\frac{0 \cdot 44 \times 100}{80} = 0 \cdot 55\% \text{ light.}$$

(xvi) In a jute mill 1000 mds. of jute was issued on a certain day. The total price of the jute issued is Rs. 25000. The standard regain is 17%. The actual regain is 21%. How the batch price be affected by this ?

Batch price $= \frac{25000}{1000} =$ Rs. 25 per md.

Actual jute issued at 17% regain $= \dfrac{1000 \times (100+17)}{(100+21)}$

$= 967$ mds.

Actual batch price $= \dfrac{25000}{967} =$ Rs. 25·85 per md.

(xvii) The average batch price in a jute mill for a month is Rs. 30. Total production for the month is 1000 tons. The consumption of jute per ton of production is 28 mds. If the consumption of jute per ton of production is 28·5 mds. how the cost of production would be affected ?

Excess consumption of jute per ton of production

$= 28{\cdot}5 - 28{\cdot}0 = 0{\cdot}5$ md.

Price of 0·5 md. jute $= 30 \times 0{\cdot}5 =$ Rs. 15

Increase in cost of production $= 1000 \times 15 =$ Rs. 15000.

CHAPTER XVII

QUALITY CONTROL IN JUTE INDUSTRY

Quality Control

Quality Control is the technique of syncronising resources in a production process to improve and maintain, with maximum economy, the quality of the product to the full satisfaction of the consumer.

Every production process has got three stages viz., specification, production and inspection. After the actual production is over, it is essential to check that the products conform well with the pre-assigned specifications. This checking over the quality of the products, leads to the acceptance of the units which conform reasonably with specifications and rejection of those which do not. A 'defective' is a unit of a product which fails to conform to specifications and every instance of the unit's lack of conformity is a 'defect'.

In mass production, the quality of all the units of the product cannot be the same. As a result of the chance causes there must be some variation among the units. This natural variability cannot be eliminated. The magnitude of the variation should be within tolerable limits. Wide variation indicates presence of assignable causes and calls for an inspection over the stages of manufacturing to trace and eliminate these causes. The quality control technique, properly applied, makes possible

the diagnosis and remedy of many production troubles and results in increase of production, improvement of product quality, minimisation of wastage and re-work and therefore reduction in cost of production.

The statistical quality control (S. Q. C.) system covers all uses of statistical techniques for the purpose of quality control. This includes mainly, the following techniques :

(i) Selection of some sample units at regular intervals of time,

(ii) Calculation of averages, ranges, deviations etc. on the basis of the data obtained from the sample units,

(iii) Preparation of graphs and control charts.

A few fundamental statistical concepts are discussed here to help the proper understanding of the methods applied in the quality control programme.

Frequency

The frequency is the number of times a variable quantity occures.

Range

The range is the difference between the highest and the lowest observed values. The lower the value of the range, the lesser the variation amongst the units.

Mean

The mean (average) is quite synonymous with the arithmetic mean. When a reading is denoted by x and there are several readings such as x_1, x_2, x_3 etc., the mean will be calculated by adding up all the values in the

series and dividing the total by the number of observations recorded.

$$\bar{x}=\frac{\Sigma x}{n}$$

where $\bar{x}$ = mean,

Σx = sum total of all the observations of x variables i.e., $(x_1+x_2+x_3+\cdots\cdots\cdots+x_n)$,

n = number of observations recorded.

Example (*i*)—To find Frequency, Range and Mean from the following data :—

Bobbin No.	(x) Tensile strength of yarn in lb. *
1	5
2	9
3	7
4	7
5	6
6	9
7	7
8	5
9	8
10	8
10 samples (n)	$\Sigma x=71$

(x) Tensile strength of yarn in lb.	Tally	Frequency of occurrence
5	//	2
6	/	1
7	///	3
8	//	2
9	//	2
		10 samples

Range $=9-5=4$ lbs.

Mean $(\bar{x})=\frac{\Sigma x}{n}=\frac{71}{10}=7{\cdot}1$ lb.

Standard Deviation

The standard deviation is a measure of variability from the mean value of a series of observations.

$$s=\sqrt{\frac{\Sigma(x-\bar{x})^2}{(n-1)}}$$

* Each reading is the average of 10 observations.

Where s = standard deviation,

x = all the individual values in the series $(x_1, x_2, \ldots\ldots\ldots x_n)$,

$\bar{x}$ = mean value of the series,

n = number of observations.

In the above formula, n may be used in place of $(n-1)$ when the size of the sample (n) is 50 or more.

The higher the value of the standard deviation, the higher the variation (dispersion of readings about the mean) and the lower the value, the lower the variation.

Example (ii)—To calculate the standard deviation from the following data :—

Bobbin No.	(x) Tensile strength of yarn in lb.	$(x-\bar{x})$	$(x-\bar{x})^2$
1	5	-2.1	4·41
2	9	$+1.9$	3·61
3	7	-0.1	0·01
4	7	-0.1	0·01
5	6	-1.1	1·21
6	9	$+1.9$	3·61
7	7	-0.1	0·01
8	5	-2.1	4·41
9	8	$+0.9$	0·81
10	8	$+0.9$	0·81
10 samples (n)	$\Sigma x = 71$	$\Sigma(x-\bar{x}) = 0$	$\Sigma(x-\bar{x})^2 = 18.90$

$$\text{Mean } (\bar{x}) = \frac{71}{10} = 7.1 \text{ lb.}$$

$$s = \sqrt{\frac{18.90}{(10-1)}} = \sqrt{\frac{18.90}{9}} = \sqrt{2.1} = 1.45 \text{ lb.}$$

Percentage Coefficient of Variation

The percentage coefficient of variation gives an idea of the dispersion of the readings about the mean. If the percentage coefficient of variation is low, it implies a strong clustering of readings round the mean. If the percentage coefficient of variation is high, it signifies that the readings are widely dispersed about the mean.

$$C.\ V.\ \% = \frac{s \times 100}{\bar{x}}$$

where $C.\ V.\ \%$ = percentage coefficient of variation,

s = standard deviation,

$\bar{x}$ = mean.

Example (iii)—To calculate the percentage coefficient of variation from the data given in *example (ii)* :—

$$C.\ V.\ \% = \frac{1{\cdot}45 \times 100}{7{\cdot}1} = 20{\cdot}4.$$

Standard Error of the Mean

The standard error of a mean gives an indication of the sampling variation or the error of estimation of the mean.

$$S.\ E. = \frac{s}{\sqrt{n}}$$

where $S.\ E.$ = standard error,

s = standard deviation,

n = number of observations.

It is evident from the above that the larger the number of observations i.e., larger the size of the sample, the lower the value of the standard error of the mean.

Example (iv)—To calculate the standard error of the mean from the data given in *example (ii)* :—

$$S.\ E. = \frac{1{\cdot}45}{\sqrt{10}} = 0{\cdot}46.$$

Random Sampling

It is neither feasible nor economical to check all the products for the purpose of quality control. Hence some samples are selected from the total number of products or intermediate stages of production at some regular intervals of time. To prevent subjective biases inherent in personal selection, table of random sampling numbers may be used to select the samples.

Table of Random Numbers

23780	28391	05940
88240	92457	89200
97523	17264	44236
80274	79932	95091
64971	49055	81905

Let us suppose there are 80 bobbins in a lot. In order to get 5 bobbins from the lot as a sample one should select the bobbins bearing the numbers 23, 80, 64, 28 and 17 and exclude the numbers 88, 97 and 92 because these are greater than the total number of bobbins. Hence the random number for selection must be either equal or less than the total number of observations under study.

Tolerance Limits

Specifications are the agreed-upon requirements, necessary in the product for maintaining its quality level.

The tolerance limits are the maximum and the minimum allowable limits, beyond which no variation is acceptable. These tolerance limits are different at different stages of production and are usually fixed before the actual production takes place. If the tolerance limits are too wide, more units with wide variations may be produced. If the tolerance limits are too close, the cost of production may be unnecessarily high. These limits may be adjusted on the basis of experience obtained from actual production.

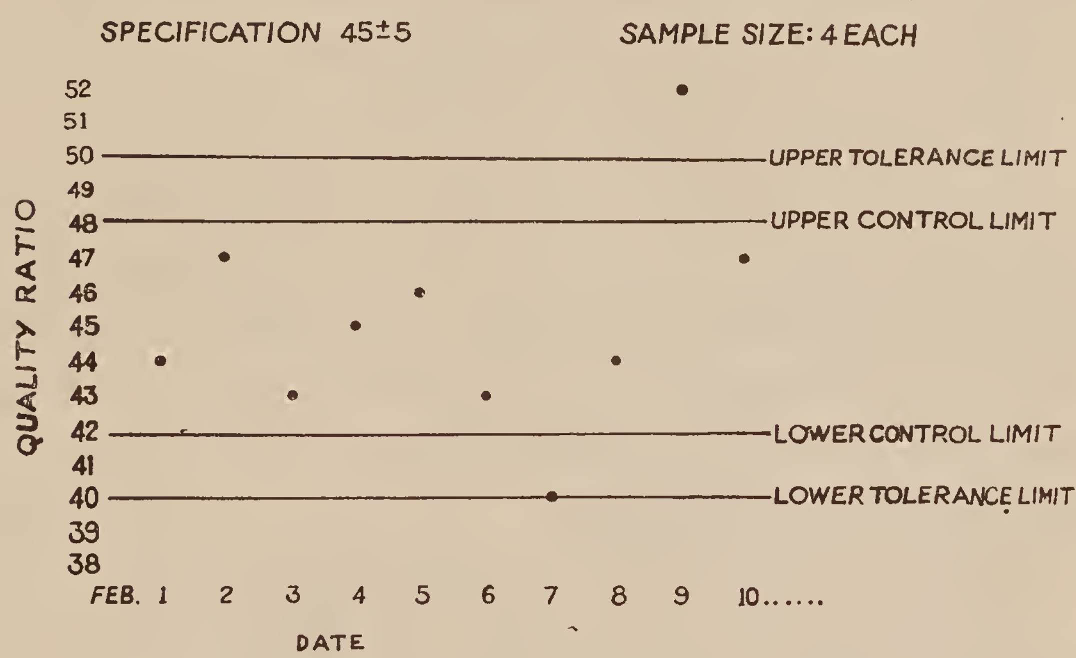
Control Chart

The control chart is a graph in which actual product quality characteristics are compared chronologically (day by day, hour by hour) with the control limits established from the past experience on the product characteristics.

The control chart is primarily designed for the prevention of defective work and also for the correction when the defects occur. The control limits are narrower than the specification limits. The control limits indicate trouble in the production process before any defective product has occurred. So long the observations are within the control limits, the production process is said to be "under control." Observations falling outside the control limits, may indicate that the process is "out of control." If proper action is taken at once the process may be under control again before any defective product occurs. Any observation outside the specification limits, means defective product has already occurred.

Let us consider the control chart for quality ratio of sacking weft yarn assuming that the specified quality ratio

is 45±5. Here the process was under control from 1st. February to 6th. February. On 7th. February the quality ratio of the yarn was lower than the lower control limit. This was traced to uneven sliver resulting from excessive application of batching emulsion on cuttings. The



Control Chart for Quality Ratio of Sacking Weft Yarn

moisture was regulated with dry thread waste and 5% long jute was increased. Next day the process was under control again. On 9th. February the observation was above the upper tolerance limit. In this case the yarn was not defective as regards quality but defective in the sense of economy. The yarn was too good ; so 5% long jute was taken out of the sacking weft batch. Nextday, again, the process was under control.

Here every reading is the average of several readings. When any reading falls beyond the control limits, more readings may be taken to ensure that the observation is not due to some error.

Control Limits

The most commonly quoted control limits in connection with normal distribution are 3σ (sigma) limits.

U. C. L. = Mean + 3σ

L. C. L. = Mean − 3σ

where U. C. L. = Upper Control Limit,

L. C. L. = Lower Control Limit,

σ = Standard Deviation.

Sometimes 2σ limits are used as warning limits.

It is not possible to standardise an inflexible rule for computation of control limits that will be applied to all the various conditions that may be encountered in practice. The following suggestions are based on experience derived from wide industrial application of the control chart.

Control Limits for Averages :

(i) U. C. L. = U. S. L. − (Average Range × F_1)

L. C. L. = L. S. L. + (Average Range × F_1)

where U. S. L. = Upper Specification Limit,

L. S. L. = Lower Specification Limit,

F_1 = Factor for use in computing control limits on product specification limits.

Table I

Sample Size	Factor (F_1)	Sample Size	Factor (F_1)
2	1·5	7	0·86
3	1·1	8	0·8
4	1·0	9	0·8
5	0·9	10	0·8
6	0·9		

(ii) U. C. L. = Grand Average + (Average Range × F_2)

L. C. L. = Grand Average − (Average Range × F_2)

where F_2 = Factor for use in computing control limits based on process grand average.

Table II

Sample Size	Factor (F_2)	Sample Size	Factor (F_2)
2	1·25	7	0·28
3	0·68	8	0·25
4	0·49	9	0·23
5	0·37	10	0·20
6	0·32		

Range Control Limit :

Average Range × F_3

where F_3 = Factor for use in computing control limit for range charts.

Table III

Sample Size	Factor (F_3)	Sample Size	Factor (F_3)
2	3·27	7	1·92
3	2·57	8	1·86
4	2·28	9	1·82
5	2·11	10	1·78
6	2·00		

Conversion of Average Range to Standard Deviation :

Average Range × F_4 = Standard Deviation

where F_4 = Factor for converting average range to standard deviation.

Table IV

Sample Size	Factor (F_4)	Sample Size	Factor (F_4)
2	0·89	7	0·37
3	0·59	8	0·35
4	0·49	9	0·34
5	0·43	10	0·33
6	0·40		

Control Limits for Percent Defective Chart :

U. C. L. = Average + (3 × S. D.)

L. C. L. = Average − (3 × S. D.)

where S. D. = Standard Deviation.

Standard Deviation of a Percentage

$$= \sqrt{\frac{\bar{p}\% \times \bar{q}\%}{\text{Sample Size}}}$$

where $\bar{p}\%$ = Average Per cent Defective,

$\bar{q}\%$ = Average Per cent Effective = $(100 - \bar{p})$

Control Limits for Defects-Per-Unit Chart :

U. C. L. = Average No. of Defects per Unit + (3 × S. D.)

L. C. L. = Average No. of Defects per Unit − (3 × S. D.)

Standard Deviation of Defects per Unit

$$= \sqrt{\frac{\text{Average No. of Defects per Unit}}{\text{Sample Size}}}$$

Control Limits for Defects-Per-Sample Chart :

U. C. L. = Average No. of Defects per Sample + (3 × S. D.)

L. C. L. = Average No. of Defects per Sample − (3 × S. D.)

Standard Deviation of Defects per Sample

$$= \sqrt{\text{Average No. of Defects per Sample}}$$

Economic Control

Sometimes the control charts indicate presence of a number of assignable causes responsible for defective units in a production process. The removal of some of these

causes, is inconvenient and expensive. In such cases, it is advisable to remove those causes, the removal of which is convenient and consistent with economy. This is known as 'economic control'.

Quality Control in Jute Industry

The object of quality control programme in jute industry is to ensure a predetermined quality of yarn and fabric at a reasonable cost. This is only possible with special attention to the quality determining factors. So the quality control programme essentially consists of performance of control tests to check the quality at every stage of production, preparation of control charts, analysis and correction of off-standard qualities whenever necessary.

Quality of Yarn

The quality of yarn is principally determined by the following factors :

(i) *batch quality,*
(ii) *machinery condition,*
(iii) *grist,*
(iv) *moisture content,*
(v) *twist,*
(vi) *tensile strength,*
(vii) *irregularity.*

A good quality batch usually yields a good yarn. To maintain the standard quality of yarn, the batch should be more or less standard in quality. To effect this, any jute in the batch should be replaced by the jute of the same district and when that is not possible, by the jute of

the nearby district. The quality of the incoming jute should be of the same standard as far as practicable. Thus, *Dhubri Middle* should be replaced by *Dhubri Middle* and when that is not available, by *Middle* of any other district, adjacent to Dhubri.

A good quality batch may yield an inferior yarn if the machines are not maintained in proper working condition, whereas with machinery in good working condition an average quality batch may produce a better yarn.

The grist of yarn should vary within tolerable limits. A light and weak fabric is the outcome if the yarn is lighter than the justified limit. The yarn heavier than the justified limit, produces heavier fabric. This means unnecessary consumption of jute and is therefore not economical.

The moisture content is important in relation to the grist of the yarn. When the yarn contains more moisture than it should contain, the yarn becomes lighter and when it contains less moisture than it should contain, the yarn becomes heavier. The nominal grist of a yarn is 8 lb. The specified moisture regain is 17%. The actual grist of the yarn is 7·5 lb. at 15% regain. The actual grist at 17% regain should be $7{\cdot}5 \times \frac{117}{115} = 7{\cdot}63$ lb. So, the yarn is light by $\frac{(8 - 7{\cdot}63)}{8} \times 100 = 4{\cdot}6\%$. It is convenient to determine the moisture regain with the help of a suitable moisture meter.

The batch quality and the required strength of the yarn, determine the degree of twist to be imparted to the

yarn. An increase in twist means corresponding decrease in production.

$$\text{Twist Factor} = \sqrt{\text{Grist}} \times \text{Turns per inch}$$

Thus, a 9 lb. yarn with 4 turns per inch has a twist factor of $\sqrt{9} \times 4 = 12$. The strength of the yarn increases as the twist factor increases until a maximum value is reached. An increase in the twist factor beyond this limit reduces the strength of the yarn. Turns per inch is usually determined on a Goodbrand ordinary twist tester using a grip length of 5 inches.

Tensile strength of the yarn is the average breaking load of a number of standard test lengths, expressed in pounds. The standard test length is usually 24 inches. A yarn strength far too below the minimum, results in low production and poor fabric quality. Again, a strength far too above the minimum, may be uneconomical. The tensile strength of the yarn is usually determined on a Goodbrand single thread tester, the rate of traverse being 12 inches per minute.

Quality Ratio is the average single-thread yarn breaking load, expressed in pounds, divided by grist and multiplied by 100.

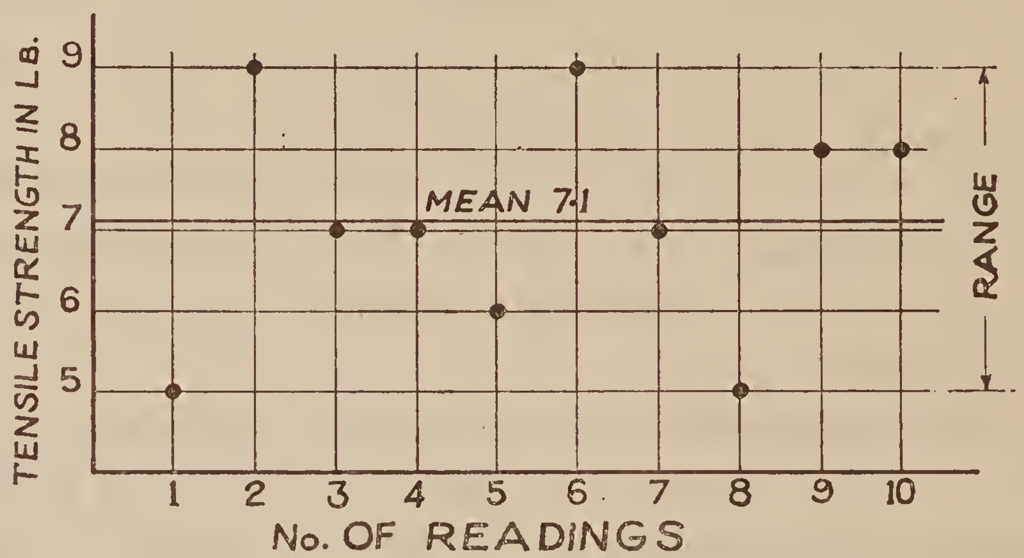
$$*\text{Quality ratio} = \frac{\text{Strength}}{\text{Grist}} \times 100$$

Thus, a 8 lb. yarn with 7·2 lb. breaking load has a *Q. R.* of $\frac{7{\cdot}2}{8} \times 100 = 90$. High quality ratio does not necessarily mean high strength as it depends not only on strength but on the grist as well. A yarn with lower quality ratio may

*The unit of quality ratio is a centispyndle.

sometimes give better performance than a yarn with higher quality ratio, if the former yarn is more regular in strength

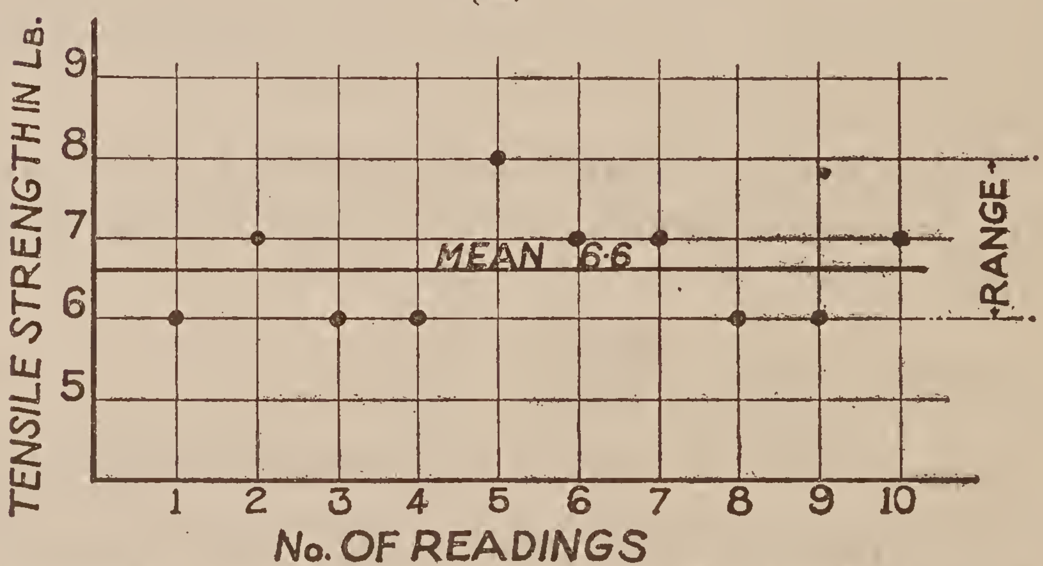
(I)



8LB./SPYNDLE YARN, Q.R.=88·75, STRENGTH C.V.% 20·42

Graph showing Higher *Q. R.* and Strength *C. V.*%

(II)



8LB./SPYNDLE YARN, Q.R.=82·50, STRENGTH C.V.% 10·60

Graph showing Lower *Q. R.* and Strength *C. V.*%

than the latter one. More irregularity in strength means more weak places in the yarn. The strength of these weak

places actually determines the behaviour of the yarn in the subsequent processes of winding and weaving.

In constant tension continuous winding test, the strength of the yarn is assessed by observing the number of breaks occurring in a given length of the yarn usually 1000 yards. The yarn is usually wound from one bobbin to another bobbin under a given predetermined tension at a speed of 75 yards per minute. This method has the advantage over the usual single-thread tester that longer lengths may be tested in much shorter time with very little or no wastage.

Yarn irregularity may be defined as the variation in diameter or cross-section from point to point. In practice, the irregularity is measured by finding the variation in weight of reasonable short lengths. The variation in irregularity is expressed as the percentage coefficient of variation of the weights of the standard lengths. High yarn irregularity reduces the yarn strength, depreciates the fabric quality and causes inefficient production. Sliver irregularity is one of the major causes of yarn irregularity.

It is not difficult to attain a reasonable standard of quality for yarn with an average quality of batch, if strict supervision is employed at every stage of production taking best advantage of quality control programme.

Quality of Fabric

The following factors mainly control the quality of fabric :

(i) *quality of component yarns,*
(ii) *weight,*

(iii) *moisture content,*
(iv) *porter and shots,*
(v) *width,*
(vi) *tensile strength,*
(vii) *faults,*
(viii) *oil content,*
(ix) *colour.*

The quality of fabric depends considerably on the quality of component yarns. Inferior quality of yarn leads to inferior quality of fabric and low production.

Normally a certain amount of variation in weight per linear yard of a fabric is expected. Change in the relative humidity also affects the fabric weight. But the weight may be kept within reasonable limits if other factors are properly controlled. Fabrics lighter than specified weight may not be accepted by the buyer, whereas heavier fabrics mean unnecessary consumption of jute and therefore a loss.

Moisture content is another factor which is to be considered in relation to the weight of the fabric. Even if the fabric shows a correct weight it is really lighter in case it contains more moisture than it should contain. Let us suppose that the standard weight of a fabric is 10 ozs. per linear yard at 17% regain. The actual weight of the fabric is 9·5 ozs. at 14% regain. The actual weight of the fabric at 17% regain should be $9{\cdot}5 \times \frac{117}{114} = 9{\cdot}75$ ozs.

Therefore, the fabric is light by $\frac{(10 - 9{\cdot}75)}{10} \times 100 = 2{\cdot}5\%$.

Deficiency in porter reduces the weight and the strength of the fabric. Under-shotting leads to reduction

of weight and strength in the fabric. Over-shotting means overweight in fabrics and also less out-put in length from the looms. The control of porter and shots within narrow limits, is possible by mechanical adjustments.

The variation in width of a fabric should be controlled within reasonable limits. Buyers may refuse to accept fabrics having width below the specification, whereas wider fabrics are uneconomical due to unnecessary consumption of jute.

To ensure a reasonable resistance to wear and tear, the fabric should have specified minimum warpway and weftway tensile strengths. $8'' \times 5'$ samples are tested for grab strength on a Scott tester (0—150 lb. capacity) with a traverse of 12 inches per minute, the dimension of the sample being $3'' \times 1''$ between the grips of the machine. The tensile strength should not go much below some predetermined value and also not far above it if the fabric must have a reasonably uniform quality.

Fabric defects are usually caused by irregular and weak yarn, defective adjustment of machinery and careless operatives. These may be avoided or at least reduced to minimum by proper adjustment of machinery and careful supervision.

Oil being cheaper than jute, there is a tendency to apply more oil to jute. · Larger quantity of oil darkens the colour and diminishes the strength of the fabric eventually. The oil content may be determined by a Soxhlet extractor using trichloroethylene or 1 : 1 alcohol benzene as solvent.

Bright colour is an important factor in hessian fabrics. The brightness may be effected by processing natural

bright jute or dark fabric may be brightened by chemical treatments. In the former case, careful selection of jute is necessary to maintain the standard brightness.

It is possible to maintain the standard quality of cloth with yarn of standard quality provided the machinery is in perfect working condition, the supervision is efficient and in harmony with quality control programme.

Problems

(i) The following quality numbers are assigned to different qualities of jute by I. J. M. A. R. I. for approximate estimation of batch quality :

Quality of Jute		Quality Number
Tossa Top	...	120
Tossa Middle	...	110
Tossa Bottom	...	105
White Top	...	105
White Middle	...	100
White Bottom	...	95
Mesta Middle	...	65
Mesta Bottom	...	60
Cutting, Habijabi, Jungli jute		35

Find the quality index of a batch consisting of 20% white middle, 10% white bottom, 20% tossa middle, 10% tossa bottom, 20% mesta middle, 10% mesta bottom and 10% cutting.

Quality index of the batch

$$=\frac{(20\times100)+(10\times95)+(20\times110)+(10\times105)+(20\times65)+(10\times60)+(10\times35)}{20+10+20+10+20+10+10}$$

$$=\frac{8450}{100}$$

$$=84{\cdot}5.$$

(ii) What should be the batch construction to have a quality index of 80 with white bottom, tossa bottom and cuttings ?

Row	Cuttings		Batch Q. N.	White Bot.	Tossa Bot.
I	35		80	95	105
II	−45	−45	0	+15	+25
III	25	15		45	45

The figures in the second row are obtained by subtracting 80 from all the quality numbers, the cuttings being considered as of two varieties with the same quality number. Now the two quantities on the left of zero are balanced against the two quantities on the right of zero. If originally there are same number of quantities on the right and the left of zero, then the splitting of a particular quality into two or more, as has been done in the present case, is not required.

The figures in the third row are obtained by reversing (disregarding the sign) the figures in the second row. The figures in the third row give the relative quantities of the three qualities of jute to be blended.

Cutting $= 25 + 15 = 40$ parts by weight
White Bot. $= 45$,, ,, ,,
Tossa Bot. $= 45$,, ,, ,,
130 ,, ,, ,,

$$\% \text{ of Cutting} = \frac{40}{130} \times 100 = 30{\cdot}77$$

$$\% \text{ of White Bot.} = \frac{45}{130} \times 100 = 34{\cdot}61$$

$$\% \text{ of Tossa Bot.} = \frac{45}{130} \times 100 = 34{\cdot}61.$$

It should be remembered that in this particular case infinite solutions are possible and the above solution is one of them.

(iii) The hessian warp yarn from 6 bobbins of a spinning frame is tested for tensile strength and the following results are obtained :

Bobbin No.	Tensile Strength in lb.										Avg. Tensile Strength in lb.
1	7·0	8·0	9·5	10·5	8·0	6·0	7·5	5·0	7·5	6·5	7·55
2	6·0	8·0	9·5	8·0	9·5	8·0	6·5	8·0	6·5	6·5	7·65
3	6·5	6·5	8·0	6·5	5·0	8·5	6·5	7·5	8·0	6·5	6·95
4	7·5	6·5	9·0	8·5	6·0	5·5	6·5	7·5	8·0	6·5	7·15
5	6·5	8·0	7·5	6·0	5·5	8·0	6·5	7·5	6·0	6·5	6·80
6	7·5	6·0	7·5	6·5	7·0	6·5	5·5	6·0	9·0	8·5	7·00
6 Bobbins											43·10

The actual grist of the yarn is found to be 8·18 lb. per spyndle. Find the quality ratio of the yarn.

$$\text{Average tensile strength of the sample} = \frac{43{\cdot}10}{6} = 7{\cdot}18 \text{ lb.}$$

$$\text{Quality Ratio} = \frac{7{\cdot}18}{8{\cdot}18} \times 100 = 87{\cdot}78.$$

(iv) The moisture regains of 10 samples of yarn from a lot are found to be as follows :

17·1, 15·5, 16·1, 16·5, 16·4, 15·0, 16·6, 16·5, 16·9, 15·9%. Find the percentage coefficient of variation.

(x)	$(x-\bar{x})$	$(x-\bar{x})^2$
17·1	+0·85	0·7225
15·5	−0·75	0·5625
16·1	−0·15	0·0225
16·5	+0·25	0·0625
16·4	+0·15	0·0225
15·0	−1·25	1·5625
16·6	+0·35	0·1225
16·5	+0·25	0·0625
16·9	+0·65	0·4225
15·9	−0·35	0·1225
162·5		3·6850

$$\bar{x}=\frac{162{\cdot}5}{10}=16{\cdot}25$$

$$s=\sqrt{\frac{3{\cdot}685}{9}}=\sqrt{0{\cdot}4094}=0{\cdot}639$$

$$C.\ V.\ \%=\frac{0{\cdot}639\times 100}{16{\cdot}25}=3{\cdot}93.$$

(v) Let us assume that the quality ratio of sacking weft yarn should be 45 ± 5. 10 samples of sacking weft yarn each consisting of 4 bobbins (sample size : 4) are tested and the results are tabulated below. Compute the control limits.

Sample No.	Bobbin No. 1	Bobbin No. 2	Bobbin No. 3	Bobbin No. 4	Sample Range
1	46	45	45	44	2
2	46	47	46	46	1
3	45	45	46	46	1
4	46	47	47	45	2
5	46	46	47	47	1
6	46	45	45	45	1
7	45	46	44	45	2
8	46	48	47	45	3
9	46	47	46	45	2
10	42	46	46	45	4
					19

$$\text{Average Range} = \frac{\text{Total of Sample Ranges}}{\text{Total No. of Samples}} = \frac{19}{10} = 1{\cdot}9$$

Upper tolerance limit $= 45 + 5 = 50$

Lower tolerance limit $= 45 - 5 = 40$

Upper control limit $= 50 - (1{\cdot}9 \times 1{\cdot}0) = 50 - 1{\cdot}9 = 48{\cdot}1$

Lower control limit $= 40 + (1{\cdot}9 \times 1{\cdot}0) = 40 + 1{\cdot}9 = 41{\cdot}9$.

(vi) Packing allowance of 10% is laid down for 40″/10 ozs. hessian fabric, L. F. W., 81″ lapped, I/B, 2000 yds. 3 bales were measured every day for a period of 10 days and the results were tabulated. Compute the upper control limit.

Date	Measurement in cubic feet			Sample Range
	Bale No. 1	Bale No. 2	Bale No. 3	
1/4	30·0	29·7	28·8	1·2
3/4	29·7	29·4	29·1	0·6
4/4	29·7	28·8	30·0	1·2
5/4	29·1	29·4	29·7	0·6
6 4	30·1	29·6	28·9	1·2
7/4	29·0	29·6	28·8	0·8
8/4	29·4	29·7	30·0	0·6
10/4	29·7	28·8	29·9	1·1
11/4	29·0	29·6	29·7	0·7
12/4	28·8	30·0	29·7	1·2
				9·2

$$\text{Average Range} = \frac{9{\cdot}2}{10} = 0{\cdot}92$$

$$\text{Standard weight of a bale} = \frac{2000 \times 10}{16} = 1250 \text{ lb.}$$

1 ton $= 50$ cubic feet

$$1250 \text{ lb.} = \frac{50 \times 1250}{2240} = 27{\cdot}9 \text{ cu. ft.}$$

$$\text{Upper specification limit} = 27{\cdot}9 \times \frac{110}{100} = 30{\cdot}7 \text{ cu. ft.}$$

$$\begin{aligned}\text{Upper control limit} &= 30{\cdot}7 - (0{\cdot}92 \times 1{\cdot}1)\\ &= 30{\cdot}7 - 1\\ &= 29{\cdot}7 \text{ cu. ft.}\end{aligned}$$

(vii) Compute the control limits for quality ratio of hessian warp yarn from the following details :

Hour	Sample Size : 3			Sample Average (rounded out)	Sample Range
	1	2	3		
8 a.m.	85	82	81	83	4
9 a.m.	80	84	86	83	6
10 a.m.	82	81	84	82	3
11 a.m.	87	86	83	85	4
12 noon	86	85	88	86	3
1 p.m.	82	84	86	84	4
2 p.m.	80	85	86	83	6
3 p.m.	84	86	85	85	2
4 p.m.	83	87	86	85	4
5 p.m.	85	83	87	85	4 .
10 Samples				841	40

$$\text{Grand Average} = \frac{841}{10} = 84{\cdot}1$$

$$\text{Average Range} = \frac{40}{10} = 4{\cdot}0$$

$$\begin{aligned}\text{Upper control limit} &= 84{\cdot}1 + (4 \times 0{\cdot}68) = 84{\cdot}1 + 2{\cdot}72\\ &= 86{\cdot}82\\ \text{Lower control limit} &= 84{\cdot}1 - (4 \times 0{\cdot}68) = 84{\cdot}1 - 2{\cdot}72\\ &= 81{\cdot}38.\end{aligned}$$

(viii) From the following frequency distribution calculate the standard deviation :

8 lb. Hessian Warp Yarn

Tensile Strength in lb.	Frequency
5	4
6	17
7	20
8	13
9	6

(*T*) Tensile Strength in lb.	(*F*) Frequency	$F \times T$	(*D*) Deviation from Average, 7	D^2	$F \times D^2$
5	4	20	−2	4	16
6	17	102	−1	1	17
7	20	140	0	0	0
8	13	104	+1	1	13
9	6	54	+2	4	24
Total	60	420			70

$$\text{Average} = \frac{420}{60} = 7$$

$$\text{Standard Deviation} = \sqrt{\frac{\text{Sum of “}F \times D^2\text{”}}{\text{Total Frequency}}}$$

$$= \sqrt{\frac{70}{60}}$$

$$= \sqrt{1{\cdot}17}$$

$$= 1{\cdot}08.$$

(ix) The count of yarn from a spinning frame was checked every hour and the results were tabulated. What should be the limits of variation in weight for which change of the draft pinion of the spinning frame is not normally considered ?

Hour	Count of yarn lb. per spyndle (x)	$(x - \bar{x})$	$(x - \bar{x})^2$
6 a. m.	8·1	+0·08	0·0064
7 a. m.	8·0	−0·02	0·0004
8 a. m.	8·2	+0·18	0·0324
9 a. m.	8·0	−0·02	0·0004
10 a. m.	7·8	−0·22	0·0484
11 a. m.	7·9	−0·12	0·0144
12 noon	8·0	−0·02	0·0004
1 p. m.	8·2	+0·18	0·0324
2 p. m.	8·1	+0·08	0·0064
3 p. m.	7·9	−0·12	0·0144
10 samples	80·2		0·1560

$$\bar{x} = \frac{80{\cdot}2}{10} = 8{\cdot}02 \text{ lb.}$$

$$\text{Standard Deviation} = \sqrt{\frac{0{\cdot}1560}{10-1}} = \sqrt{\frac{0{\cdot}1560}{9}} = \sqrt{0{\cdot}0173}$$
$$= 0{\cdot}132$$

Upper limit $= 8{\cdot}02 + (2 \times 0{\cdot}132) = 8{\cdot}28$ lb.

Lower limit $= 8{\cdot}02 - (2 \times 0{\cdot}132) = 7{\cdot}76$ lb.

So long the count of the yarn from the spinning frame varies between 7·76 lb. and 8·28 lb. change of draft pinion is not normally considered. If one or two points go beyond the control lines immediate steps should not be

taken. One should wait and see if the departure is really not accidental. If the readings persist to exceed the control lines, the cause for variation should be looked for.

(x) A sample of 200 hessian bags from each lot was inspected for bag size and the observations were tabulated below. Compute the upper control limit for per cent defective.

Lot No.	Defectives in Sample of 200	Percent Defective
1	4	2
2	2	1
3	8	4
4	6	3
5	4	2
6	2	1
7	4	2
8	4	2
9	2	1
10	4	2
Total	40	20
Average	4·0	2·0

$$\text{Standard Deviation} = \sqrt{\frac{2\% \times 98\%}{200}} = 0{\cdot}99\%$$

$$\text{Upper control limit} = 2{\cdot}0 + (3 \times 0{\cdot}99) = 4{\cdot}97\%$$

In this case, computation of the lower control limit is not essential as for finished bags, the less the number of defective units, the better.

(xi) In a spinning department, sliver spinning frames, each containing 100 spindles, were employed for the manufacture of hessian warp yarn. Compute the control

limits for per cent idle spindle from the data given below and comment on the findings.

Date	No. of Frames	No. of Spindles	No. of Idle Spindles	Percent Idle Spindle
1/3	10	1000	40	4
2/3	9	900	18	2
3/3	11	1100	77	7
4/3	11	1100	110	10
6/3	11	1100	55	5
7/3	10	1000	30	3
8/3	9	900	27	3
9/3	9	900	18	2
10/3	10	1000	40	4
11/3	10	1000	30	3
Average	10	1000		4·3

$$\text{Standard Deviation} = \sqrt{\frac{4{\cdot}3\% \times 95{\cdot}7\%}{1000}} = 0{\cdot}64$$

$$\text{Upper control limit} = 4{\cdot}3 + (3 \times 0{\cdot}64) = 6{\cdot}2$$
$$\text{Lower control limit} = 4{\cdot}3 - (3 \times 0{\cdot}64) = 2{\cdot}4.$$

The out-of-control points on 3rd. and 4th. March were traced to presence of hard roots in the sliver. The root-ends were properly cleaned in the batching department and the process was again under control on 6th. March.

The lower the number of idle spindles in the spinning process, the better the efficiency. From this point of view, computation of the lower control limit is not necessary. But this may be considered from another angle. If the percent idle spindle is below the lower control limit, it is economical to reduce the batch index taking care that

the percent idle spindle does not exceed the upper control limit.

(xii) 10 bales of B twill bags each containing 300 pieces were selected from a lot. The bales were opened, inspected and the results were tabulated. Compute the control limits for the defects-per-sample chart.

Bale No.	No. of Defective Bags per Bale
1	6
2	4
3	2
4	8
5	4
6	4
7	6
8	10
9	2
10	4
Total	50

$$\text{Average Defective Bags per Sample} = \frac{50}{10} = 5$$

$$\text{Standard Deviation} = \sqrt{5} = 2{\cdot}24$$

$$\text{Upper control limit} = 5 + (3 \times 2{\cdot}24) = 11{\cdot}72$$

$$\text{Lower control limit} = 5 - (3 \times 2{\cdot}24) = -1{\cdot}72.$$

As the lower limit is less than zero, we should disregard the lower limit on the control chart.

(xiii) The specification of a hessian fabric, tolerance limits and the observed values are given. Analyse the findings and find out to what extent the quality of the fabric is affected by the variation from the specified values. What steps should be suggested for quality control ?

Particulars	Specifications	Tolerance Limits	Observed Values	Variation % + or −	Inference
Width	40 in.	±1%	40·25 in.	+0·63%	Reasonable
Weight per linear yd.	10 ozs. at 16% regain	±2%	9·9 ozs. at 14% regain	+0·8% at 16% regain	Reasonable
Porter	11	±2%	11	—	Correct
Shots/in.	12	±2%	11	−8·3%	Far too short
Warpway strength	85 lb.	±5%	82 lb.	−3·53%	Reasonable
Weftway strength	95 lb.	±5%	85 lb.	−10·52%	Far too short
Colour	Light	—	Average	—	Passable
Oil content	Below 4%	—	5%	—	High
Faults	Nil	—	A few reed-marks and specks	—	Passable

To control the quality of the fabric, shotting should be improved to the reasonable level. Better shotting, in turn, will improve the weftway strength. Less batching oil should be applied to jute in the batching department

so that the oil content does not exceed 4% limit. Hessian weft batch may be improved if necessary. Careful selection and cleaning of root-ends in the batching department will reduce the specks. Reed-marks may be avoided by adjustment in the loom.

CHAPTER XVIII

METRIC SYSTEM AND JUTE INDUSTRY

English System

Length

12 inches (in.)	=	1 foot (ft.)
3 feet	=	1 yard (yd.)

Weight

16 ounces (oz.)	=	1 pound (lb.)
28 pounds	=	1 quarter (qr.)
4 quarters	=	1 hundredweight (cwt.)
20 hundredweights	=	1 ton

Capacity

4 gills	=	1 pint
2 pints	=	1 quart
4 quarts	=	1 gallon

Metric System

Length

100 centimetres (cm.)	=	1 metre (m.)
1000 metres	=	1 kilometre (km.)

Weight

1000 grams (gm.)	=	1 kilogram (kg.)
100 kilograms	=	1 quintal
1000 kilograms	=	1 metric ton

1 gram is the weight of 1 cubic centimetre of water at 4°C.

Capacity

100 centilitres	=	1 litre
1000 litres	=	1 kilolitre

1 litre is 1 kilogram of water at 4°C.

Indian System

Weight

5 tolas	=	1 chatak (ch.)
16 chataks	=	1 seer (sr.)
40 seers	=	1 maund (md.)

Conversion Factors

Weight

1 ounce = 28·3495 grams = 2·43056 tolas
1 pound = 0·453592 kilogram = 0·486111 seer
1 ton = 1·016046 metric tons = 27·22222 maunds
1 gram = 0·035274 ounce = 0·085735 tolas
1 kilogram = 2·204622 pounds = 1·07169 seers
1 metric ton = 0·984206 ton = 26·7923 maunds
1 tola = 11·6638 grams = 0·411429 ounce
1 seer = 0·933104 kilogram = 2·05714 pounds
1 maund = 37·324142 kilograms = 0·0367347 ton

Length

1 inch = 2·539999 centimetres
1 yard = 0·914399 metres
1 centimetre = 0·393701 inch
1 metre = 1·093614 yards

Capacity

1 gallon = 4·5459631 litres = 0·160544 cubic feet
1 litre = 0·2199753 gallons = 0·0353156 cubic feet
1 cubic feet = 6·228822 gallons = 28·316098 litres

Metric Equivalents of a few Standard Cloth Sizes

Quality		Existing Specifications		Metric Equivalents	
	P × S	in.	oz.	cm.	gm.
Hessian	6 × 6	40	— 6·0	101·6	— 170
,,	7 × 8	40	— 6·5	101·6	— 184
,,	9 × 9	40	— 7·5	101·6	— 213
,,	9 × 10	40	— 8·0	101·6	— 227
,,	9 × 10	40	— 9·0	101·6	— 255
,,	11 × 10	40	— 9·5	101·6	— 269
,,	11 × 12	40	— 10·0	101·6	— 283
,,	11 × 12	40	— 12·0	101·6	— 340
,,	11 × 12	45	— 11·0	114·3	— 312
Twill					
Sacking	6 × 8	27	— 14·0	68·6	— 397
,,	8 × 8	27	— 16·0	68·6	— 454
,,	7 × 9	30	— 15·0	76·2	— 425
,,	8 × 8	30	— 17·0	76·2	— 482

Metric Equivalents of a few Standard Bag Sizes

Hessian Bags

Quality P × S	Existing Specifications: Size of Bag in.	Existing Specifications: Weight per Bag lb.	Metric Equivalents: Size of Bag cm.	Metric Equivalents: Weight per Bag gm.
Onion Pockets Hd. (9 × 10)	40 × 22·5	0·75	101·6 × 57·1	340
Wheat Bags Hd. (11 × 12)	36 × 22	0·75	91·4 × 55·9	340
Australian Bran Bags Selv. (11 × 12)	49 × 30	1·25	124·5 × 76·2	567
Fizi Bags Hd. (11 × 15)	36 × 22	1·00	91·4 × 55·9	454
Cotton Packs Hd. (9 × 10)	85 × 45	3·00	215·9 × 114·3	1361

Plain Sacking Bags

Quality P × S	Existing Specifications: Size of Bag in.	Existing Specifications: Weight per Bag lb.	Metric Equivalents: Size of Bag cm.	Metric Equivalents: Weight per Bag gm.
Heavy Cee Bags Hd. (8 × 9)	40 × 28	2·25	101·6 × 71·1	1021
Light Cee Bags Hd. (8 × 8)	40 × 28	2·00	101·6 × 71·1	907
D. W. Flour Bags Hd. (7 × 9)	56 × 28	2·50	142·2 × 71·1	1134
D. W. Salt Bags Hd. (6 × 8)	45 × 26	1·75	114·3 × 66·0	794

Twill Sacking Bags

Quality P × S	Existing Specifications: Size of Bag in.	Existing Specifications: Weight per Bag lb.	Metric Equivalents: Size of Bag cm.	Metric Equivalents: Weight per Bag gm.
A. Twills Hd. (8 × 9)	44 × 26·5	2·625	111·8 × 67·3	1191
B. Twills Hd. (6 × 8)	44 × 26·5	2·25	111·8 × 67·3	1021
Liverpool Twills Hd. (8 × 8)	44 × 26·5	2·50	111·8 × 67·3	1134
Cuban Sugar Bags Hd. (8 × 8)	48 × 29	2·50	121·9 × 73·7	1134
Egyptian Sugar Bags Hd. (6 × 8)	48 × 28	2·50	121·9 × 71·1	1134
Australian Corn Sacks Hd. (8 × 9)	41 × 23	2·25	104·1 × 58·4	1021
Egyptian Grain Sacks Hd. (6 × 8)	60 × 30	5·00	152·4 × 76·2	2268
Australian Wool Packs Hd. (8 × 9)	54 × 27 × 27	11·25	137·2 × 68·6 × 68·6	5103
Cement Bags Hd. (8 × 8)	36 × 22	1·6875	91·4 × 55·9	765
Twill Ore Pockets Selv. (8 × 8)	30 × 20	1·50	76·2 × 50·8	680

CHAPTER XIX

A FEW DEFINITIONS AND FORMULÆ

Density

The density of a material is the mass contained in unit volume of the material. It is usually expressed as gram per cubic centimetre.

Specific Gravity

The specific gravity of a substance is the ratio of the weight of a definite volume of the substance to the weight of an equal volume of water at 4° C. The determination of the specific gravity of batching oil is important. Usually hydrometers are employed for this purpose.

Humidity

Absolute humidity is the quantity of aqueous vapour present in a given volume of atmospheric air.

Relative humidity is the mass of aqueous vapour present in a given volume of air at any temperature expressed as a percentage of the mass of aqueous vapour required to saturate the given volume of air at the same temperature. 'Wet and dry bulb hygrometer' is commonly used to determine the relative humidity.

Viscosity

The viscosity of a liquid is its resistance to flow. The more viscous the liquid, the less fluid it is. Usually the time of flow of a definite volume of a liquid is compared

with that of some standard liquid at a given temperature. 'Red Wood Viscometer' is often used to determine the viscosity of the dressing mixture.

Horse-power

Horse-power (H. P.) is the unit rate of working in the British system and is equivalent to 33000 lb. raised 1 ft. high per minute.

1 horse-power	= 550 foot pound per second
	= 33000 foot pound per minute
	= 746 watts (electrical equivalent)
	= 0·746 kilowatt
1 watt	= 0·7376 foot pound per second
	= 0·001341 horse-power
1 foot pound per second	= 1·35573 watts
1 kilowatt-hour	= 2654200 foot pounds
	= 1·3411 horse-power hour

The kilowatt-hour is the commercial unit for the supply of electrical energy and is called the 'Board of Trade Unit'.

Electrical Units

Volt	= the practical unit of electromotive force.
Ohm	= the practical unit of resistance.
Ampere	= the practical unit of current density.
Watt	= the practical unit of rate of working.
Joule	= the mechanical equivalent of heat (= 1 watt per second).
Watts	= amperes × volts.

$$\text{Watts} = \frac{\text{joules}}{\text{seconds}}$$

$$\text{Effective H. P.} = \frac{\text{Watts}}{746}$$

Foot pounds per minute = Watts × 44·236.

H. P. = kilowatts × 1·34.

Conversion Factors for Thermometer Scales

From Centigrade scale to Fahrenheit scale :

$$°F = \frac{9 \times °C}{5} + 32$$

From Fahrenheit scale to Centigrade scale :

$$°C = \frac{5(°F - 32)}{9}$$

Capacity of Vessels

(i) Rectangular vessel :

$$\frac{L \text{ in.} \times B \text{ in.} \times H \text{ in.} \times 6{\cdot}23}{1728} \text{ gallons}$$

$$\frac{L \text{ cm.} \times B \text{ cm.} \times H \text{ cm.}}{1000} \text{ litres.}$$

(ii) Cylindrical vessel :

$$\frac{\pi (R \text{ in.})^2 \times L \text{ in.} \times 6{\cdot}23}{1728} \text{ gallons}$$

$$\frac{\pi (R \text{ cm.})^2 \times L \text{ cm.}}{1000} \text{ litres}$$

L = length, B = breadth, H = height

R = radius, $\pi = \frac{22}{7}$

$2\pi R$ = Circumference of a circle

πR^2 = Area contained by a circle.

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1. Hanton, W. A.—Mechanics of Textile Machinery
2. Morley, A. & Inchley, W.—Elementary Applied Mechanics
3. Smith, A.—Jute Spinning Calculations
4. Woodhouse, T. & Kilgour, P.—Jute and Jute Spinning
5. Woodhouse, T. & Ireland, J.—An Introduction to Jute Weaving
6. Woodhouse, T. & Milne, J.—Jute and Linen Weaving
7. Woodhouse, T. —The Finishing of Jute and Linen Fabrics
8. British Standard 1133 : Section 9 : 1950
9. Lomax, J.—Textile Testing
10. Grant, E. L.—Statistical Quality Control
11. Enrick, N. L.—Quality Control
12. Journal of the American Statistical Association, Volume 48, Number 264, December 1953
13. I. C. J. C.—Technological Research Leaflets No. 2, 3, 4, 5, 6, 16, 17
14. I. J. M. A. R. I.—Quality Control and Quality Grading Scheme
15. Banerjee, B. L.—The Constant Tension Continuous Winding Test in Yarn Testing with Particular Reference to Jute Yarns (The Indian Textile Journal, Bombay, April 1960)
16. I. J. M. A.—Metric Conversion Tables for the Jute Industry

INDEX

The present work, the third on the subject by the author, is the most up-to-date and authoritative reference-book on jute technology ever published in this country.

The book deals in a concise manner with all the various processes of jute manufacture from batching to finishing and includes all necessary calculations and description of both old machinery and modern mill machinery. A special feature of the book is the inclusion of a chapter on Statistical Quality Control. Another useful chapter is the chapter on Metric System as applied to jute industry.

A large number of line drawings specially commissioned for this work are distributed throughout the book, serving both to supplement and clarify the text.

The book will prove immensely helpful to students, apprentices and technologists, and even persons in the top management will find it interesting.

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